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FAUNA

OF THE

CHILKA LAKE.

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[*N.B.*—An asterisk (*) preceding a line denotes a new variety or subspecies ; a dagger (†) indicates a new species ; a double dagger (‡) a new genus or subgenus ; synonyms are printed in italics.]

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MEMOIRS OF THE INDIAN MUSEUM, VOL. V.

FAUNA OF THE CHILKA LAKE

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FAUNA OF THE CHILKA LAKE

PREFACE.

Some years ago a series of short papers on the fauna of brackish pools at Port Canning in the Gangetic delta was published in the *Records of the Indian Museum.* I had intended to make these the basis of a much more comprehensive study of the fauna of brackish water in Bengal and other parts of India, but as time went on it became evident that the area of these pools was too limited, and their biological equilibrium too subject to interference on the part of man, for them to be regarded as in any way typical. On several occasions I had visited the Chilka Lake for the purpose of collecting the animals of its shores and islands, but it was not until July, 1913, when bottom-nets were used for the first time, that the real interest of the lake fauna became apparent. On this occasion I was so struck by the association of marine and freshwater forms that I sent to Calcutta for Mr. Kemp to join me at Barkul and we drew up together a scheme for a comprehensive zoological survey of the lake.

In due course our plan was laid before the Trustees of the Indian Museum, who accepted it in a most generous spirit and put aside ample funds for its realization. With their approval we hired the only steam-launch on the lake, obtained the necessary apparatus by purchase from Europe or from local sources and arranged to spend, together or severally, a considerable part of the year 1914 on the lake or its shores.

I take this opportunity to state that all the physical observations whereby the positions of our collecting-stations were established and the varying salinity of the water ascertained were made by Mr. Kemp, whose practical experience of marine investigations is more extensive than my own.

So far as the preparation of this volume is concerned, we have worked in the strictest collaboration, and even those reports that are issued in the name of one of us have had the benefit of revision at the hands of the other. Our acknowledgment of the assistance we have received is expressed in a general manner in the Introduction that follows; in the case of reports on the groups that we have not ventured to discuss ourselves from a taxonomic point of view, the papers themselves will provide the best proof of our indebtedness.

N. ANNANDALE,
Superintendent of the Indian Museum.

CALCUTTA:
May 14th, 1915.

FAUNA OF THE CHILKA LAKE

INTRODUCTION.

By N. ANNANDALE, *D.Sc.*, *and* STANLEY KEMP, *B.A.*

(Plates I and II.)

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FAUNA OF THE CHILKA LAKE

INTRODUCTION.

By N. ANNANDALE *and* STANLEY KEMP.

GEOGRAPHY OF THE LAKE.

Its position and character.

The Chilka Lake is a lagoon situated on the east coast of Peninsular India and connected with the Bay of Bengal. Its area is about 350 sq. miles; its depth rarely exceeds two fathoms; its water undergoes great changes of salinity in the course of the year and at any one season differs greatly in this respect at different places. The precise geographical situation of the lake is between latitudes 19°28′ and 19°54′ N. and longitudes 85°6′ and 85°35′ E.; the greater part of it lies in the Puri District of the Province of Bihar and Orissa, while one corner extends into the Ganjam District of the Madras Presidency.

Its divisions.

A glance at the map (plate II) will show that the lake consists of two parts, (*i*) an outer channel opening to the sea and (*ii*) what may conveniently be called the main area.

The outer channel is peculiar in that its course is not direct from the sea to the lagoon, but runs parallel to both for some miles. Its total length is about twelve miles and the breadth of the outer part nowhere more than one and a quarter. The actual mouth of this channel changes from time to time both in position and in breadth; in 1914 it was situated opposite the village of Arakhuda and was not more than 300 yards broad. Near the opening the channel turns abruptly at right angles to its former course and communicates with the sea by a narrow passage several hundred yards in length and apparently of no great depth. There are records that on several occasions the mouth has been completely blocked up by sand carried along the coast by northerly currents, especially in the south-west monsoon.[1] It has then been opened artificially by digging to prevent flooding of the surrounding country.

From the inner opening of the sea-passage the channel runs almost directly south-west. On one side it is separated from the sea by a narrow sand-spit and on the other from the main area of the lake by a series of comparatively broad peninsulas and islands. On reaching the apex of the Satpara peninsula the channel divides into two branches, one of which continues in the original course until it becomes gradually merged in a network of swamps and narrow water-ways. The broader branch, however, turns at a right angle and, continuing round Satpara peninsula,

[1] The origin and direction of the local currents on this coast are still very imperfectly known, and it is probable that more than one factor plays a part in the phenomenon to which we refer.

finally reaches the main area at the point called Mugger-Mukh[1] (Shark mouth). In the flood-season this is one of two openings into the main area, for there is another south-west of the large flat island of Barnikuda which lies in the midst of the inner part of the channel; but even the opening at Mugger-Mukh becomes extremely shallow in the dry season, while the other disappears altogether. In March there is not more than a foot and a half of water on the bar at the former point.

The main area of the Chilka Lake is the real lagoon and occupies by far the greater part of the lake-system. It is roughly pear-shaped, the longer axis running south-west and north-east. Its length is about forty miles in the height of the dry season and its greatest breadth about twelve and a half miles. The broadest point is situated toward the north-east extremity.

Shores, streams and islands.

The shores of the Chilka Lake have considerable variety of character. Smooth green lawns, diversified by clumps of trees, slope down to the water's edge: rocky headlands rise as pyramids, seemingly composed of loose boulders piled one on another with bamboos and other vegetation springing up in the interstices; islands, some bare and rocky, others like the headlands, others again low and sandy, rise from the surface of the water; naked sand-hills contrast with the dark green foliage in which fishing villages lie hidden.

On a near approach the green lawns are not attractive, for in dry weather their margins are edged with decaying weed and in the rainy season lie deep in evil-smelling mud: the headlands and islands are difficult of access at all times of the year. Our present business, however, is not to discuss the beauties or the discomforts of the Chilka Lake but to describe the features of its shores that have a bearing, direct or indirect, on the nature and distribution of its fauna.

At the northern end of the main area the silt brought down by several branches of the Mahanaddi system, of which the most important is the Dayanaddi, has formed a margin so ill-defined that, when the floods are high and the water in consequence fresh, there is no perceptible boundary between rice-fields and lake; the former terminate only at the point at which the water becomes too deep for rice to grow. As the water-level sinks in late autumn wide stretches of muddy foreshore are left bare.

Along the outer side of this area, as the distance from the mouth of the streams increases, a large quantity of sea-sand is mixed with the mud, and even where the proportion of alluvium present is very small, the periodic decay of vegetation and the fine silt usually held in suspension in the water but deposited when a dead calm prevails, produce a thinner or thicker layer of mud above the sand. Along the whole of this shore the extent of mud or sand left bare when the water sinks is considerable and the depth of the lake at and near the margin extremely small, to be measured in inches rather than feet.

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[1] In several Indian dialects the word "mugger" (more correctly *magar*) means crocodile; but the Uriya fishermen of the Chilka Lake use it to signify either a crocodile, a porpoise or a shark. The last is sometimes distinguished as *magar-mach* and the porpoise (*Orcella brevirostris*) as *sus-magar*.

Nov. 1914. Rocks near Patsahanipur.

Nov. 1914. Foreshore near Barkul. Bemrose, Collo., Derby

VIEWS OF THE CHILKA LAKE.

The inner side of the main area has a far more varied character. For some miles north-east of Barkul, almost to the point at which the delta of the branches of the Mahanaddi may be said to commence, the shore consists of a series of little bays separated by headlands of the kind described above. Most of these headlands are spurs running out from a range of rocky hills that lies almost parallel to and at no great distance from this shore; others are isolated fragments of the same formation. Between the promontories the edge of the lake is flat and resembles that of the outer shore of the same area, except that the proportion of mud to sand is greater at most points and the slope a little less gentle; single rocks and groups of stones, most of which are left entirely bare in winter, occur sparingly; the grass that covers the shore is short and coarse.

South-west of Barkul point, which forms a lower and less pyramidal promontory than those that lie to the north-east, there are several wider bays in which the margin is of a similar kind, but without the headlands

The south (strictly south-west) end of the lake is occupied by two long and rather narrow bays separated by a mass of rocky hills, the highest of which, a regular pyramid named Ganta Sila, rises almost straight from the water to a height of over 500 feet and is one of the most conspicuous land-marks over the greater part of the whole area. Round its base single rocks of considerable size form what may almost be called small cliffs; when the lake is flooded or moderately full the water round them is several feet deep, but in spring and early summer a narrow muddy foreshore is left bare in front of them. The shores of the two bays resemble those adjacent to them.

Near the south-western corner of the outer bay lies the mouth of a small canal that formerly ran to the town of Ganjam, which is connected by another canal with the Bay of Bengal. The Chilka-Ganjam canal is now, however, completely blocked up and the locks with which it was provided must always have rendered any direct communication between the lacustrine fauna and that of the sea practically impossible.

The inner shore of the outer channel, except in the immediate neighbourhood of the sea-opening, resembles the outer shore of the lagoon. The bar that separates the channel from the Bay of Bengal is, however, composed almost entirely of clean sea-sand sloping down into the water, and it is only at the point at which the channel turns landwards, and in particular opposite Barhampur Id., that the margin becomes muddy or swampy.

The only streams of any size that find their way into the lake are the branches of the Mahanaddi that enter the north-eastern part of the main area, for the hills that run parallel to the inner shore are practically waterless for the greater part of the year and even at the southern end the small water-courses dry up more or less completely by the beginning of the hot weather.

In the main area of the lake there are a number of rocky islands of different sizes, none of them really large, that have a certain biological importance in that

their bases remain under water throughout the year. In this area there are also a few flatter and more sandy islands the margins of which slope gradually, but the most remarkable and the largest island in the whole lake is Nalbano, which lies not very far within the Mugger-Mukh. Nalbano is a great sand-bank completely covered with tall reeds, the roots of which are submerged when the water is high, so that only the leaves and inflorescences are visible above the surface.

The islands of the outer channel, including Barnikuda, are also sand-banks, but at most support in the way of vegetation no more than a scanty growth of short grass with, in the case of Barnikuda, a few stunted shrubs.

Bottom.

Generally speaking the bottom of the main area is muddy, while that of the outer part of the outer channel is sandy. In the former its nature is so uniform, notwithstanding the admixture of a certain amount of sand at some places, that the small actual differences have as a rule little effect on the fauna, and it is only in the neighbourhood of Nalbano and on the shores of some of the other islands that true arenicolous species occur in this area. The mud forms two quite distinct layers, one of which remains practically undisturbed except in very rough weather, while the other is usually held suspended in the water and only deposited in very sheltered places or at times of unusual calm. This floating layer is of course very finely divided and habitually stains the water a dirty clay-colour. Its occasional deposition is an unfavourable factor in the life of many sessile organisms. The permanent layer is gray and of a clayey consistency, but not so tenacious or so heavy as that of creeks and canals in the Gangetic delta. It is mixed with a considerable amount of decayed vegetable matter, which sometimes stains it black, and often with a large number of small dead shells of genera such as *Clementia*, *Theora*, *Nassa*, *Stenothyra*, etc. These apparently do not remain long intact; but at certain points, notably in the neighbourhood of Gopkuda Id., there are fairly large deposits of dead *Placuna*-shells, which are evidently more permanent, while at the edge of Rambha Bay masses of crude lime are dug from the mud when the water sinks and with them occur large numbers of dead shells of *Arca* and *Meretrix*. These deposits of calcareous matter do not, however, seem to have any direct effect on the fauna found amongst them.

In the inner part of the outer channel there is a great mixture of mud and sand, some of the latter being black and extremely heavy. Mr. G. H. Tipper of the Geological Survey of India informs us that this is due to the presence of monazite in small quantities.

In the part of the outer channel that runs parallel to the Bay of Bengal, the bottom is composed of almost pure yellow sand similar to that which forms the beach along the greater part of the eastern shore of Peninsular India. The only natural solid bodies found in this part of the lake are the large masses of dead and living oyster-shells that lie in beds round the small islands opposite the village of Manikpatna. The faunistic importance of the absence of solid bodies is illustrated by the fact that on a small post set up to mark the channel near Satpara we found several species not obtained anywhere else in the lake.

Depths.

The main area of the Chilka Lake is exceedingly shallow. In the dry season, when the water-level is at its lowest, the depth rarely exceeds 8 ft. at the southern end; while over an immense area towards the northern extremity it nowhere reaches 4 ft. The deepest sounding we obtained at this season was 10 ft., at a point close to the eastern end of Kalidai Id., whence a comparatively deep trough extends towards the shores of Parikudh. At many places we found it impossible to approach within a mile of the shore even in a small row-boat.

We have already referred to the shallowness of the water at Mugger-Mukh and to the depth of the outer channel at this season. The deepest water is said to be situated off Arakhuda and our boatmen talked of five fathoms; but the deepest soundings we ourselves obtained did not exceed 20 ft.

In the flood-season all depths are increased by 5 or 6 ft., the exact amount probably varying from year to year.

It is evident that the differences in depth, relatively great though they may be, are actually insufficient to produce any appreciable effect on the fauna of different parts of the lake, except in so far as they imply a great rise of temperature in extremely shallow water.

Origin of the lake.

The origin of the Chilka Lake was thus explained by the late Dr. W. T. Blanford in his "Sketch of the Geology of Orissa"[1]:—

"The lake itself is a part of the sea first rendered shallow by deposits from the mouths of the Mahanaddi and from silt carried up the bay round the hills near Ganjam by the violent southerly winds of the monsoon, and then entirely cut off by a spit, formed, by the same agency, of sand drifted along the coast. Near the south-western extremity of this spit there is a considerable deposit of estuarine shells, at a height of 20 to 30 feet above the present flood level of the Chilka."

For our special purpose it is unnecessary to elaborate this concise statement, with which we are in general agreement.[2] We may point out, however, that even stronger evidence for the belief that the lake was once an open bay than that adduced in the passage quoted, is to be found in the occurrence on the rocks at the base Ganta Sila of the remains of solitary corals, organisms that flourish only in a pure sea-water. The beds of dead *Placuna*-shells to which we have already alluded provide evidence less strong, for *Placuna* flourishes in the Tampalakaman (Tamblegam) Lake[3] on the coast of Ceylon, in which conditions are not very dissimilar to those of the Chilka Lake.

HYDROGRAPHY OF THE LAKE.

Of the varied elements that compose the physical environment of the fauna of the lake by far the most noteworthy is the great periodic change in salinity to which

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[1] *Rec. Geol. Surv. India*, V, p. 56 (1872).

[2] Hunter, in his "*Orissa*" (p. 25; 1872) cites a legend which implies that the bed of the lake was dry land as late as the 4th century A.D.

[3] Hornell, "Report on the Placuna Placenta Pearl Fishery of Lake Tampalakamam": *Rep. Ceylon Marine Biol. Lab.*, I, p. 41 (1906).

its waters are subject. This factor undoubtedly exercises a continual selective influence on the animals of the lake and it is to it, in the main, that the special interest of the fauna is due.

The methods which we adopted in determining the salinity of the water are explained on p. 17.

As is pointed out below (p. 18) our investigations were made chiefly at two periods, in each of which we attempted, so far as was possible, to visit all parts of the lake. Observations were, of course, made at other seasons and we have in fact, in 1914 and in previous years, paid visits to the lake in practically every month; on these occasions, however, our investigations were of a more or less restricted nature, concerning only a portion of the area to be investigated.

The more comprehensive surveys effected in the two periods mentioned above were made respectively in the salt- and the freshwater seasons. In the first, in which our observations extended from February 12th to March 18th, the entire lake was filled with water of varying but comparatively high density, while in the second, from September 1st to September 23rd, the water throughout a great part of the system was quite fresh, owing to the floods which enter the lake at the close of the monsoon.

The charts on p. 9 showing the corrected specific gravity of the water will give a good idea of the enormous variation in density at these two periods. It is of course improbable that they represent the maximum and minimun with any exactitude. Somewhat higher specific gravities are doubtless to be found in early summer, that is to say in the period immediately preceding the monsoon, and subsidiary investigations made in July tend to prove that this is the case. It is also possible that the general density indicated in fig. 2 is capable of further reduction in exceptionally high floods so far as the southern end of the lake is concerned.

In giving an account of the general configuration of the lake-system, we noticed that it could be divided into two parts, the main area, which comprises the bulk of its waters, and the outer channel that forms the communication with the sea. This division is not founded entirely on geographical considerations; there are also very marked differences in the range of density of the water in the two regions and therefore notable faunistic distinctions.[1] The division is consequently based on both physical and biological features of considerable importance.

Salinity of the outer channel.

In March we found that the specific gravity of the sea, taken at a point some miles below the mouth (and therefore, owing to the strong north-easterly currents that prevail along the coast, uncontaminated by any discharge from the lake) was 1·0270. An additional observation made a few days later just inside the mouth gave a reading of 1·02825. At this period there was no appreciable outflow from the lake and the water in the channel over an area extending from Barnikuda Id. to Arakhuda yielded specific

[1] The prevalence of a sandy bottom over a large part of the outer channel must also of course be taken into account in considering the faunistic differences.

gravities varying from 1·02625 to 1·02650.[1] It is clear that in this region, during March, the water was for all practical purposes as salt as the sea.

In September the conditions were markedly different. The level of the water was some five feet higher than in March and many of the low-lying islands in the channel were almost or entirely submerged, a strong current was flowing out of the lake and the water throughout the length of the channel was entirely fresh up to the point where it entered the sea. Ebb and flow at this period made no alteration in salinity and the maximum effect even of a high spring tide could only have been a slight banking of the water at the mouth. The specific gravity of the sea a little to the south of the entrance to the lake was at this period 1 01675, a reading considerably lower than those obtained in March of the same year.

By December the freshwater floods had in a large measure subsided and samples taken in the early part of this month at Satpara and near Manikpatna gave readings respectively of 1·00325 and 1·01250. At this time a small outflow from the lake probably still persisted, salt water entering the channel only at high tide or under specially favourable conditions of wind.

In the outer channel, then, the range of salinity is the greatest possible, and animals that live permanently in this region are able to exist for some eight months in water almost or quite as salt as the neighbouring sea (sp. gr. 1·0270) and for at least three months in water that is entirely fresh.

The change from salt to fresh water that takes place annually towards the close of the monsoon season is probably effected gradually. The discharge from the rivers at the northern end of the lake must in the first place drive before it the saline water with which the main area was previously filled, and there can be no doubt that the first slow currents that pass down the outer channel have a comparatively high salinity, which slowly decreases with the augmenting volume of the flood. The change from fresh to salt water, on the other hand, probably takes place more suddenly. After the floods have subsided and the head of water in the lake has disappeared, there must, under suitable conditions of tide and perhaps also of wind, come a time when a volume of salt water enters the sea-mouth and it is possible that far-reaching alterations take place in the channel in the course of a single day.

Both periods of change must have marked effects on the fauna of the outer channel and on each occasion there is probably a high mortality; freshwater forms must be largely exterminated on the entrance of salt water, while many marine species that have established themselves during the salt-water period must succumb in the flood season. We have direct evidence that this occurs.

Salinity of the main area.

Though less extensive than is the case with the outer channel, the changes of density to which the waters of the main area are subject are nevertheless great; the specific gravity varying, according to our observations, from 1·000 to 1·0150.

[1] A sample taken in a swamp south-east of the northern extremity of Barhampur Id. and separated by a bar from the main channel gave a reading 1·02376. The water in this place was probably mixed with a certain amount of surface drainage from land in the vicinity.

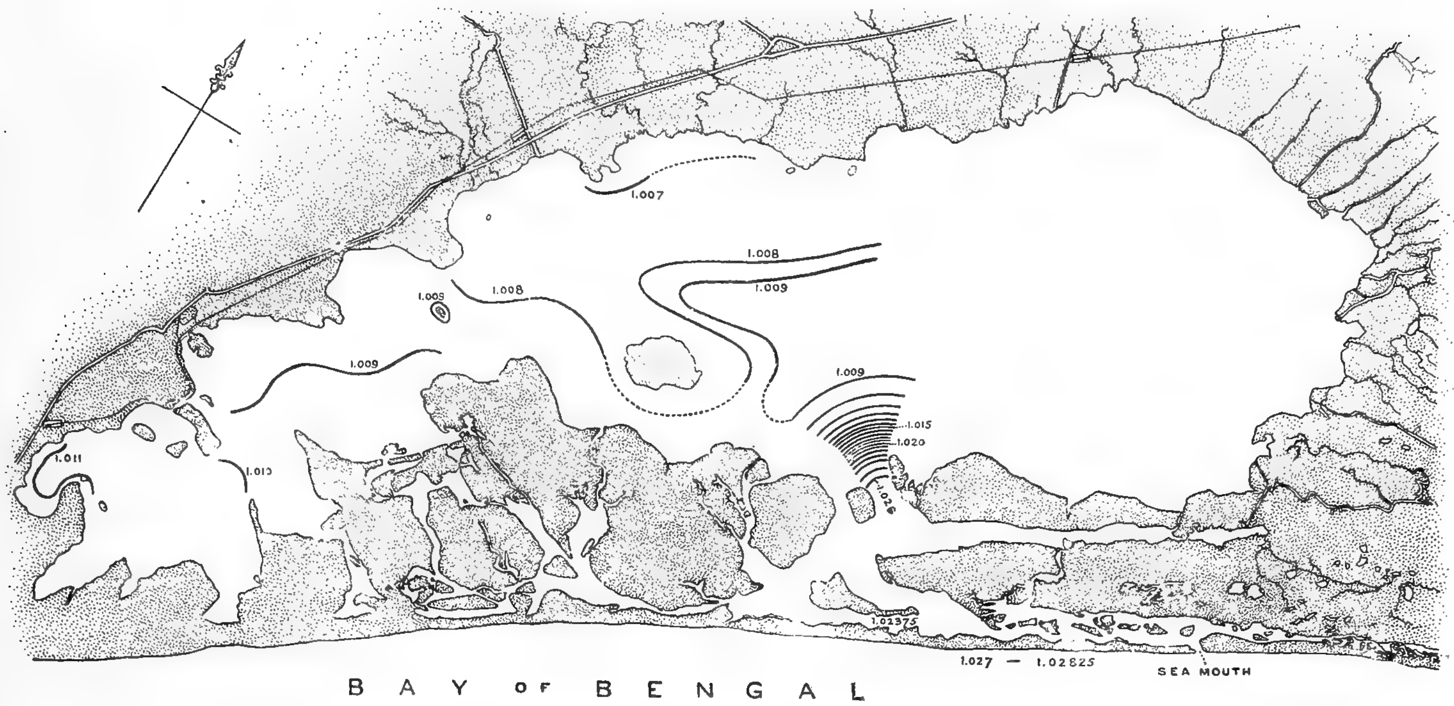
In February and March, as will be seen from the chart on p. 9, an abrupt change in density was encountered at Mugger-Mukh on the bar that separates the main area from the outer channel—a bar covered at this period by water only some eighteen inches or two feet in depth. The specific gravities in little more than a mile changed from 1·026 to 1·010. The floods of the previous year's monsoon had not only altogether subsided, but a considerable quantity of salt-water had entered from the Bay of Bengal. The most noteworthy feature of the specific gravities in this large region was that the denser water was accumulated at the south end. The highest readings were obtained at the southern extremity of Rambha Bay and from this point to Nalbano the specific gravities regularly decreased. North of Nalbano, water of greater density was again met with, while the lowest readings were obtained along the north-western shore in the vicinity of Patsahanipur. At this period the specific gravities we obtained ranged from 1·00675 to 1·01150. Owing to the extreme shallowness of the lake we were unable, however, to visit a considerable region at the northern end and the comparatively small amount of water that enters from the rivers probably produces specific gravities lower than any we actually recorded.

Subsidiary observations made in the middle of April at the southern end of the lake seem to indicate that no great change in the conditions had taken place, though the position of the isohalines (as indicated by the lines of equal specific gravities) had probably altered to a certain extent. Samples taken in Rambha Bay and off Breakfast and Chiriya Ids. gave readings identical with those of February; but off Barkuda the specific gravity was lower (1·00975) and off Maludaikuda higher (1·00975). By July, however, a notable change had occurred and there is little doubt that during May and June a considerable volume of salt water had entered the lake; the specific gravities were higher than any previously observed and the entire area southwest of Samal Id. was filled with water varying from 1·0145 to 1·0150. At Barkul the specific gravity was still much the same as in February, *viz.*, 1·00750.

The conditions in the main area were very different in September, 1914. In this month, as shown in fig. 2, p. 9, the greater part of the area was filled with fresh or almost fresh water.

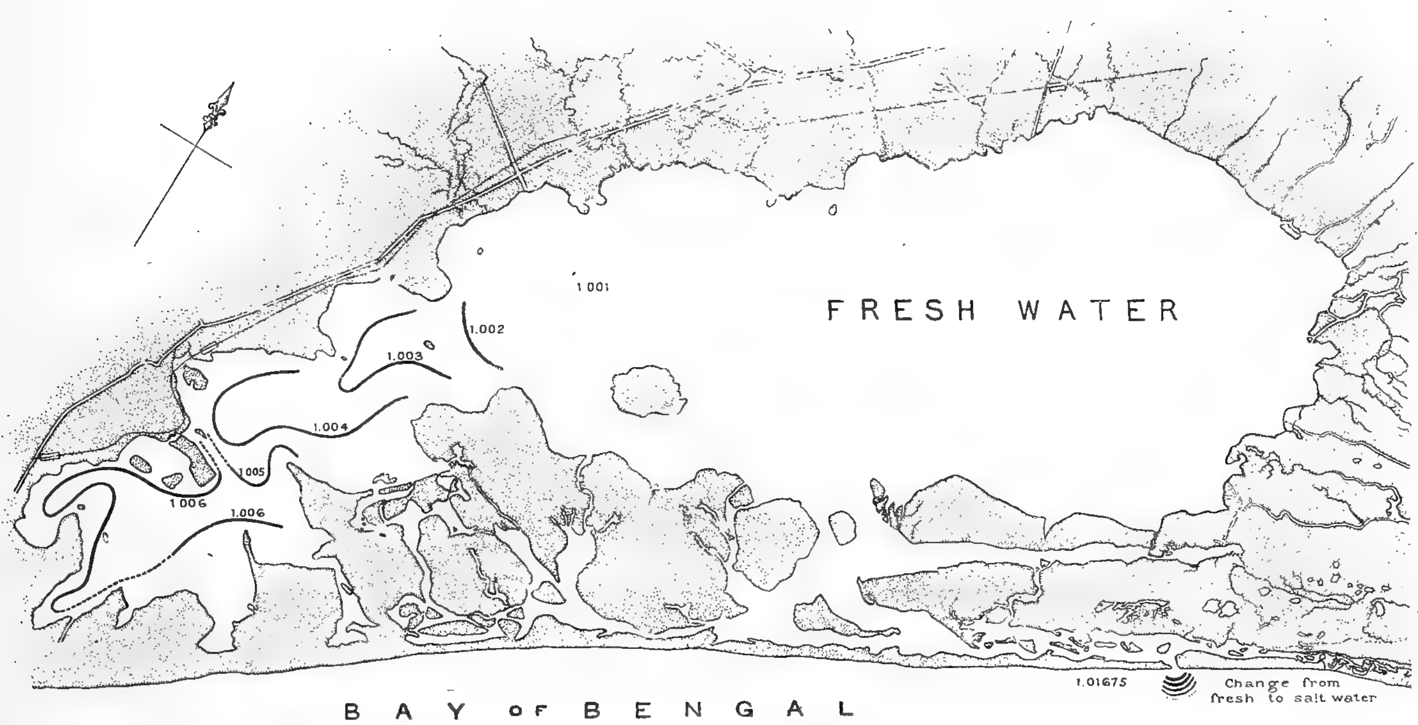
The great volume of silt-laden water brought down into the northern end by the branches of the Mahanaddi system had expelled all that of higher salinity—a phenomenon already noted with reference to the outer channel. It is evident that, in these parts of the lake at any rate, the changes are not due to admixture so much as to the expulsion of one volume by another.

In September slight traces of a higher specific gravity were met with between Nalbano and Patsahanipur, the water varying from fresh to 1·001, and southwards of this line there was a gradual rise in density up to sp. gr. 1·0065 in Rambha Bay. The latter reading, the maximum observed in September, is about the same as the minimum recorded in the salt-water season. It will be noticed that specific gravities of 1·006 and over were only met with near the shore in the extreme south and that



TEXT-FIG. 1.—The specific gravity of the water of the lake in February and March, 1914.

At this period we were unable to visit the north-east end of the lake owing to the shallowness of the water. The specific gravities recorded in the main area varied from 1·00675 to 1·0115. A sudden change occurred at Mugger-Mukh,[1] the outer channel being filled with water as salt as that of the Bay of Bengal.



TEXT-FIG. 2.—The specific gravity of the water of the lake in September, 1914.

During this month the water-level was some 6 ft. higher than in February and March; Nalbano[1] and several of the islands in the outer channel were submerged. The north-eastern part of the main area was filled with fresh water, as was also the outer channel as far as the sea-mouth. In the south-western end of the main area the specific gravities ranged from 1·002 to 1·0065.

[1] See detailed map, Plate II

throughout the southern part of the lake the water in the middle was of lower specific gravity than that nearer the shores.

A short series of observations made in November indicates that the conditions in this month did not differ largely from those observed two months earlier, the highest specific gravity (1·006) being obtained at the south end of Rambha Bay. Water of appreciable salinity was, however, not so closely restricted to the southern area, for a sample obtained off Kalidai gave a reading of 1·0035 and others off Barkul of 1·003. The flood-waters had somewhat abated, with the result that the level had decreased and the saline water, confined during September at the extreme south, had spread further north.

It is noteworthy that the rocks on the inner shore of the main area appear to indicate that the water sinks mainly in a series of sudden falls, for, as will be seen from the upper photograph on Plate I, the stone is marked in the dry season with three or four horizontal bands of a superficial nature. The distinct demarcation of these bands is apparently due to the fact that the upper limit of each has indicated the highest water-line for some considerable period, and after a high south-westerly wind we noticed in one case that a band actually represented an area of half-dried alga just left bare by a sudden reduction of level.

Effect of winds, tides, etc.

An attempt to discuss in detail the various other agencies that affect the salinity of the lake would be beyond the scope of our present enquiry and would certainly demand an experience of hydrography and meteorology which neither of us possesses. It has been our object to obtain, so far as was practicable within the limits of a single year, a general idea of the alterations in salinity to which the fauna of the lake is subject and of the more important causes to which these changes are due.

It is evident that the changes are to a large extent correlated with differences in water-level and that the monsoon floods are by far the most potent of the agencies at work. Other causes must, none the less, have a marked effect Although the rivers at the north bring with them by far the greater part of the fresh water that enters the system, the streams which occur in the monsoon at other points but are for the most part dry during the remainder of the year, must also have some influence on the conditions and during periods of heavy rain surface drainage even from the small watersheds at the southern end must be considerable.

Unfortunately no precise data are available as to the amount of rain that falls actually on the lake; in our experience it was decidedly less (in 1914) than that which fell on the surrounding country. Storms coming up from the south often either followed the hill-ranges to the north-west of the lake, or else split in two before they reached it, one part skirting these hills while the other keeps to seaward, following the line of sand-hills along the coast.

An important factor in local changes in salinity is the direction of the wind. Owing probably to the topography of the surrounding country the monsoon currents are to some extent diverted and the prevalent wind throughout the greater part of the year is south-westerly. From this quarter it often blows with considerable

force and for protracted periods. We are informed that on occasions, when its violence is extreme, the greater part of Rambha Bay is entirely emptied of water and in February, 1914, the effect of even a moderate breeze was brought home to us by a sudden lowering of the water-level so great that the "Lady of Chilka" grounded at her moorings. Sudden changes of the kind must result in the water being banked up towards the northern end and must produce a considerable admixture of volumes hitherto distinct. Observations made at Barkuda Id. in February, before and after several days' strong breeze, showed a definite rise in density, the salter water having doubtless been brought from the southern end by the wind.

Tides have of course no effect during the flood season, as at this period the outer channel is filled with fresh water to a level some feet above that of the sea. Even when the lake was at its lowest we were unable to observe any regular ebb and flow in the main area. The influence of wind, indeed, seemed to us sufficient to account for any diurnal changes in level that were actually noted. Any effects that the tides may have had were doubtless masked by this agency, while we made no attempt to investigate less obvious movements.

In the outer channel tide had of course a slight effect at this season; but the rise and fall, owing to the narrowness of the sea-mouth, was probably much smaller than in the Bay of Bengal immediately outside. It is clear, nevertheless, that the tides, assisted probably by changes in the wind, must have a much greater effect on the isohalines than is indicated by diurnal changes in water-level, for to this agency in a large measure must be assigned the influx of salt water at the time when the autumn floods have subsided.

In a lagoon of the size and shallowness of the Chilka Lake evaporation must, especially in a tropical climate, be more than considerable and doubtless plays a great part in the phenomena we have been discussing. We have no means of estimating the exact influence of this factor, but it is not unreasonable to suppose that beyond compensating for the comparatively small amount of fresh water that comes from the Mahanaddi system in the dry season, it also plays an important part in inducing an inflow from the sea.

Summary statement of annual changes in salinity.

The great changes in the salinity of the Chilka Lake are due, as has already been explained, to the floods of fresh water which enter it each year at the northern end from several branches of the Mahanaddi system; the annual sequence of events, as it concerns the lake as a whole, may be stated briefly as follows:—

The floods that enter the lake at the close of the monsoon from the Mahanaddi delta expel all salt water from the northern portion, driving it through the outer channel to the sea, and are of sufficient volume to raise the level of the lake some 5 or 6 ft. above the mean of the dry season. There being no outlet at the southern end, the comparatively saline water which had accumulated there is banked up by the flood, becoming, however, diluted to a considerable extent both by admixture with water from the north and by surface drainage from the land in the vicinity. Towards the end of the year the floods subside. The first effect of the alteration

in level is that the water of low salinity, hitherto confined at the southern end, spreads further north. In course of time the level sinks to a minimum and subsequently, under suitable conditions of wind and tide, volumes of salt water enter from the sea and entirely fill the outer channel. This in 1914 had already taken place before the month of February. Under normal conditions the waters of the main area probably rise in salinity, owing to successive inflows from the Bay of Bengal, until a maximum is reached in July. By August the monsoon floods have commenced, the water-level rises rapidly and a repetition of the annual cycle begins.

The important subject of salinities may therefore be summarized as follows:—

(1) In the dry season the water of the outer channel is practically as salt as that of the Bay of Bengal, while that of the main area is distinctly brackish.

(2) At the end of the wet season the water of the whole of the outer channel and of a great part of the main area is fresh, while that of the south-western part of the latter is but slightly saline.

(3) At all times of year the change from water of low to that of comparatively high salinity take places abruptly in a very limited area, so that the isohalines are closely crowded together.

(4) In the dry season this area of abrupt change is situated at the junction of the outer channel with the main area, but by the end of the wet season it has shifted to the sea-mouth.

Temperatures.

Variations in the temperature of the water of the lake have probably, except in extreme cases, but little influence on the distribution of the fauna. According to our observations, the surface temperature ranges from 25° to 35°C. and is probably higher to a marked extent than that of the Bay of Bengal. The cooler water is naturally found in the more central parts, while nearer the shores, and especially in the vicinity of rocky headlands, the temperature is noticeably higher. Even comparatively short periods of hot weather must obviously have a marked effect in raising the surface temperature and the maximum must be reached in very shallow water or in small more or less isolated pools at the margin. In one such spot we obtained, in March, a reading of 43°C.; this temperature must be inimical to many forms of life and as a matter of observation few living animals are to be found in situations of the kind. Seasonal variation in temperature is certainly not very great: but our data are not sufficiently extensive to permit of a more precise statement.

VEGETATION.

In most parts of the lake the aquatic vegetation is scanty, but in a few sheltered bays in the main area a species of *Potamogeton*[1] with slender, grass-like leaves grows

[1] Probably *P. pectinatus*, Linn. We have to thank Dr. D. Hooper for the name of this plant.

luxuriantly, forming dense thickets that extend upward from the bottom to the surface for a height of at least four feet. This plant dies down in the rainy season and masses of dead and dying weed then break loose, float on the water and are thrown up on the shore or entangled amongst rocks at the edge. The new growth makes its appearance in autumn and is well advanced by the middle of November, when the plant is in flower on the surface. Its maximum luxuriance is not, however, reached until February or March, after the flowering season is practically over.

A plant more widely distributed in both parts of the lake, but much less conspicuous and luxuriant, is *Halophila ovata*, a species that creeps along the bottom sending up stems of four to six inches high at short intervals. These bear relatively large ovate leaves which form a favourite basis for a few simply organized sessile animals. *Halophila*, which is practically confined to a muddy bottom, is found all over the main area and in the inner part of the outer channel, in patches that often reach a considerable size. Small masses of this plant are constantly being detached, probably by diving ducks and other water-birds, and float from place to place. The plant is found in an active condition at all times of the year.

Several other aquatic Phanerogams occur in the lake, but are not of sufficient abundance to have any faunistic interest.

Among semi-aquatic flowering plants by far the most conspicuous is the reed (*Phragmites*) that covers Nalbano and grows among the rocks on many of the promontories. It reaches a height of at least 10 feet. Several other smaller grasses and at least one species of rush also grow in the shallows of the main area, but not in sufficient quantities to attract a special fauna.

The higher algae are absent from the lake and those of the less specialized groups that occur are not as a rule of any great zoological interest. Several unicellular forms are found, however, in considerable quantities in the plancton at some seasons, notably species of Dinoflagellata, while a certain number of diatoms live on the bottom or elsewhere. Submerged rocks and stones are usually coated with simple and branched filamentous algae of a bright green or a brown colour, but the growth is never very luxuriant. A slimy dark green species with an offensive odour sometimes covers small patches of the bottom in the main area and is fairly common along the shore of the Satpara peninsula. Its presence seems to be peculiarly inimical to animal life. As the water sinks after the rains, this alga, in drying, forms a thin felt-like substance and is gathered by the villagers at Satpara and used by them instead of paper for wrapping up parcels.

From a zoological point of view the most important feature of the vegetation on the shores of the lake is the total absence of mangrove swamps. Except where the beach is sandy, as along the outer parts of the outer channel, or stony, as around many of the islands and promontories of the main area, cultivated fields or grazing grounds extend down to the water's edge, if the former do not actually encroach upon the water. There are, therefore, comparatively few trees close to the margin; firewood is also scarce and trunks and branches are not allowed to go to waste or to float away. This fact is of faunistic importance in reference to the

general scarcity of solid bodies to which attention has already been called with respect to the outer channel. The hedges of screw-pines by which the fields are protected from trespassing cattle are, however, when the water is high, sometimes partially submerged; they then afford shelter to many Decapod crustacea, while broken fragments stranded on the shore give lodgment to amphibious insects and crustacea, as well as to several terrestrial vertebrates that feed on these animals.

GENERAL CHARACTER OF THE FAUNA.

When all the reports contributed by specialists to this volume have been completed we propose to discuss the fauna of the Chilka Lake in considerable detail. It will be well, however, to preface these reports by a brief statement as to the general nature of the fauna with which they will deal. To do so it will be convenient to consider the animals first under the following headings:—

(1) Mud fauna.
(2) Sand fauna.
(3) Rock fauna.
(4) Weed fauna.
(5) Free-swimming organisms.
(6) Plancton and surface fauna generally.

1. The organisms that live in mud or crawl on its surface form what is perhaps from a zoological point of view the most conspicuous element in the fauna of the lake. Considering the great proportion of the bottom that is covered with mud this fact is not surprising. Among the mud-dwellers are included several coelenterates, several polychaete worms, a large proportion of the molluscs, several Decapod and other crustacea, a few small Teleostean fish and several comparatively large rays. In nearly every case the number of species present in any one group is extremely small, indeed it is probable that in many cases even families are each represented by a single form. The number of individuals on the other hand is as a rule very large. In this section of the fauna we find many noteworthy adaptations for burrowing and for protecting the gills or other breathing apparatus from being clogged with particles of silt.

2. The arenicolous animals of the lake are mainly confined to the outer part of the outer channel and have as a rule a less specialized character than the mud-dwellers. Among them are to be found at least one species of sponge, two species of oligochaete worms, several polychaetes, and the majority of the Decapod crustacea and molluscs. This element is not entirely confined to the outer channel, for several of its representatives are found on the shores of Nalbano Id. and a few even so far inland as Barkuda Id. near the mouth of Rambha Bay.

3. The rock fauna is much more restricted as to number of species and genera than might at first sight seem probable. The sponges are represented by two abundant forms, the coelenterates by a single hydroid, the crustacea and worms by a few small species that crawl among sponges and algae or hide under stones; the molluscs by one or two sessile Lamellibranchs and one or two Gastropods. The poverty of this element is due very largely to two facts, firstly that most of the rocks are only covered by water for a small part of the year, and secondly that any animal

which settles on a flat surface is liable to be smothered by the deposition of fine silt in calm weather.

4. The majority of the animals that can be classed under the heading of weed fauna are associated either with *Potamogeton* or with *Halophila*. Young fish of many species take shelter amongst the dense thickets of the former plant, to which the insects of the lake are, at any rate in the salt-water season, almost entirely confined. Several species of Decapod crustacea and at least one very abundant Lamellibranch mollusc are also characteristic of these thickets. The comparatively large leaves of *Halophila* act as a base for several small sponges, coelenterates and polyzoa. On the whole the scantiness of the fauna associated with weeds is a little surprising.

5. Under the heading of free-swimming organisms we must include the majority of the fish, as well as a few medusae and at least one Ctenophore, also several Decapod crustacea and at least three species of Mysidacea. As a rule the animals falling under it are perhaps the least interesting with which we have to deal, and it has been impossible, except in a very few instances, to add materially to our knowledge of their biology or distribution.

6. We are hardly in a position as yet to say much about the plancton beyond stating that in the main area of the lake it is never abundant and almost disappears for a time in the earlier part of the rainy season, while in the outer channel it becomes, in the salt-water season, both more abundant and more varied than it ever is inside Mugger-Mukh. One point may be noted, however, *viz.*, that in most of our samples from the main area Copepods and larval molluscs greatly predominate.

We have not included among the headings tabulated above that of 'amphibious fauna,' as perhaps we might have done. There are of course a certain number of crustacea, insects and other animals that would naturally fall into this category ; but the amphibious fauna fades so gradually into the terrestrial one, with which we do not propose to deal, that it has seemed best to consider separately the status of each species that lives only partially in water.

Regarded as a whole, the fauna of the lake may be described as mainly of marine origin. A few freshwater forms have, however, established themselves, while there is also a marked faunistic element that appears to have originated actually in estuaries or backwaters subject to great changes of salinity and temperature. This element is also well represented in the Gangetic delta and in lagoons on both coasts of Peninsular India. A fourth element consists of species that immigrate at appropriate seasons either from the sea or from neighbouring streams, ponds and rice-fields, while a fifth—of little importance—is composed of mere casual visitors that drift, swim or crawl into the lake and exist there for a period without establishing their species among its permanent inhabitants.

The abundance of individuals and poverty of species noticed under the heading of mud fauna is to a very large extent characteristic of the fauna generally and in particular of that of the main area.

Perhaps the most striking feature of the biology of the permanent residents in the lake is the extraordinary power of individual adaptability to physical changes

in environment that most of them possess. It seems strange to find a Rhizostomous medusa or an Oxystome crab living in lacustrine conditions, but it is even more remarkable that individuals of such forms are able to flourish at one season in fresh and at another in salt water.

AIMS OF THE ZOOLOGICAL SURVEY OF THE LAKE.

The origin of our zoological survey of the Chilka Lake has been explained in the note prefixed to this volume; the main object we have had before us in its execution has been to lay a foundation for the study of the fauna of brackish water and of water of variable salinity on the coast of India on the same lines as our predecessors in the Indian Museum have done for that of the abyssal fauna of Indian seas. For this object it has seemed necessary in the first place to make our collections as comprehensive as possible, noting the circumstances of each capture and deducing from our notes facts as to the biology of the commoner species. It has not been possible, and perhaps it has been hardly desirable, to make any attempt at a detailed biological or morphological study of any particular group or species. That can come later, and if our researches prove useful to future naturalists who may undertake investigations of the kind, we feel that our labours will be amply rewarded. In a field so little explored we think it is as well not to specialize too soon.

The methods employed and the apparatus used in the survey may be described in some little detail.

METHODS AND MATERIAL.

Apparatus.

In making our investigations we were fortunate in obtaining from the Kallikota *raj* the use of a small launch, the "Lady of Chilka", the only steamship on the lake. From this launch we were able to trawl systematically over a considerable part of the main area and, in the flood-season, over the whole of the outer channel. In the latter area, in the salt-water season, we worked from a row-boat kindly lent us by the Salt Department.

The very soft mud of which the bottom is for the most part composed proved a considerable difficulty, and we believe that a really satisfactory instrument for the zoological investigation of regions such as the Chilka Lake yet remains to be devised. A net with mesh fine enough to retain small bottom organisms, such as Cumacea and minute Mollusca, does not permit the mud to escape and in a very short space of time becomes filled to bursting point.

For bottom work we used chiefly two sorts of net. The first of these was a miniature beam-trawl, six feet in breadth, of a size that could be fished comfortably from the stern of the launch. At the cod-end the mesh of this net was $\frac{1}{2}$ in. (stretched) and it therefore permitted the greater part of the mud to escape, except in particular places where it was of a lumpy character. To the back of this net, on the outside, we attached a shaped bag of mosquito-netting or coarse-meshed canvas, placed in the path of the swirl caused by the foot-rope. This net caught numbers of small

animals which would otherwise have escaped, and compensated in some measure for the large mesh of the main bag: none the less it was frequently drawn up half full of mud.

The second type of net employed for bottom work was a ⌓-net, that is to say a light frame of $\frac{5}{8}$ in. iron (shaped in the form of a ⌓ and towed by three bridles) to which by means of brass rings a long bag of coarse-meshed canvas was attached. This net produced excellent results; but it was only possible to make very short hauls as the bag rapidly filled with mud.

Mud we dealt with by means of a series of large rectangular sieves with brass meshing, fitted in a frame to keep them above the level of the deck.

A larger net, an otter-trawl with head-rope 28 ft. in length and 3 in. mesh at the cod-end, was also employed occasionally and was successful in obtaining large fish that were able to avoid the smaller nets, especially in thickets of *Potamogeton* near the shore.

The larger free-swimming organisms were obtained by towing the ⌓-net in midwater and at the surface; but for many of the fish we were dependent on indigenous methods, which will be described in a special paper in this volume. Plancton we collected in silk tow-nets of the ordinary type supplied by the Marine Biological Station at Plymouth. Hand-nets were of course employed in shore-collecting, in which we found a hammer and chisel an essential part of our outfit.

As regards determinations of salinities it seemed unnecessary, in view of the enormous seasonal changes, to employ the elaborate titration method advocated by the Bureau International pour l'Exploration de la Mer, a method designed to demonstrate extremely slight differences in oceanic and coastal waters. We realized at the outset that to obtain a complete or even an approximate knowledge of the varied physical conditions that affect the salinity of the lake would be beyond our powers and that it was improbable that observations carried out in a single year, however complete, would render possible a true account of the actual changes that take place. Variations in rainfall, temperature, wind, tide and possibly other factors must all produce different effects in different years

In making our observations on the density of the water we used a hydrometer kindly lent us by Capt. R. B. Seymour Sewell, Surgeon-Naturalist to the Marine Survey of India, and our results are therefore expressed in the form of specific gravities. The scale of the instrument, which is calibrated for 15°C., is about 7 cms. in length and is graduated from 1·00 to 1·04 in 40 divisions. Readings were taken to the nearest 0·00025. In order to give corrected readings of specific gravities of 1·0015 and under it was necessary, at the temperature at which we were working, that the hydrometer should be scaled below 1 000. This unfortunately was not the case and we are in consequence unable to insert the line representing sp. gr. 1·001 in the chart reproduced in fig. 2 on p. 9.

Water-samples were collected in bottles provided with a spring top and rubber washer and were, as a rule, tested the day they were taken. The determinations quoted are in every case reduced to 15°C. by the use of a correction table. This table is based on a series of laboratory experiments made with the same instrument

in waters of different salinities at temperatures ranging from 10° to 35°C. We are under great obligation to Dr. W. A. K. Christie, Chemist to the Geological Survey of India, for advice and practical assistance in this matter.

The positions of our stations in the lake were determined by the use of a sounding quintant and station-pointer kindly lent us by the Survey of India.

Collections.

The specimens on which the reports in this volume are based are at present in the Indian Museum, in which all the types of new species described, as well as a complete set of all other forms, will be preserved. The oldest specimens from the Chilka Lake that we possess are a few shells collected by the late Dr. W. T. Blanford and his agents, mostly, as is evident from the species represented, in the outer channel. The Museum collector obtained a considerable number of fish in the neighbourhood of Gopkuda Id. in 1907, while Dr. J. Travis Jenkins made collections, also mainly of fish, in the outer channel in 1908. One of the present authors paid a short visit to Rambha in the following year and obtained there, among other material, the types of several new shells described by Mr. H. B. Preston. It was not, however, until August, 1913, that any concerted attempt was made to investigate the bottom-fauna. In that year we used bottom-nets for the first time in the lake, mainly in the immediate neighbourhood of Barkul. In October of the same year we commenced preliminary work at Satpara and Rambha, and subsidiary trips were made in November and in the following January. Our actual survey commenced in February, 1914. Apart from a number of short visits to one or other region of the lake, it was conducted, as has already been stated, mainly at two periods, representing respectively the middle of the salt-water and that of the fresh-water season. In February and March we spent altogether about six weeks on the lake, on which we trawled practically every day, while in September a period of about three weeks was occupied in the same manner. Our own shorter trips were made in April, July, November and the beginning of December, while Dr. B. L. Chaudhuri collected fish at Barkul and elsewhere in December of the same year and in January, 1915

We have in our log particulars of 171 collecting stations. In some cases the data of two or more stations refer to the same place at different seasons, but many specimens were collected, on the subsidiary trips and at other times, in circumstances not noted in the log, though recorded on the labels.

The bulk of the collections is of course very considerable and it will therefore be possible for us to distribute to other museums by the only means open to us (*i.e.*, that of exchange) a number of sets of duplicates.

LIMITATIONS OF THE WORK.

Neither the time nor the funds at our disposal were unlimited and even within the somewhat narrow boundaries to which the survey was confined, we were obliged to observe certain limitations in collecting. Generally speaking we made no special effort to capture and preserve representatives of microscopic groups such as the

Protozoa and Rotatoria. The smaller Entomostraca were collected merely as they occurred in tow-nettings. In the majority of groups larval forms, with a few specific exceptions, were also neglected, while certain other small and inconspicuous organisms (*e.g.*, the free-living Nematodes) were obtained only in small numbers.

We regret that we were unable to study the ornithology of the lake, which is remarkably attractive at different seasons to different kinds of water-birds, though comparatively few breed there habitually.

In a few groups of animals of which we did make fairly comprehensive collections, it has not been possible in the present state of international affairs to find specialists able and willing to investigate the specimens. The most noteworthy of these groups are the Nemertea and the aquatic beetles. Of the former at least three species are common in the main area of the lake, while both the Dytiscidae and the Hydrophilidae are represented by a considerable, but not a large, number of forms. We failed to get the two species of Nudibranch molluscs that occur identified, while the single Tunicate we obtained (an immature Appendicularian common in the outer channel in March) is probably not determinable specifically.

Among internal parasitic species we preserved a certain number of Helminthes, especially Cestoda from the alimentary canal of sting-rays. Mr. T. Southwell has also collected specimens of this group in the lake and is preparing a report upon his and our collections.[1] The parasitic Nematodes are poorly represented and there is only one Acanthocephelon, which was found in the intestine of a Teleostean fish. The Trematodes are represented by at least three species, a large and common form from the body-cavity of a ray and two minute Distomids, one occurring in the canals of a Ctenophore and the other in the body-cavity of a Copepod. We do not propose to discuss these internal parasites further except in reference to their hosts.

Of the groups that appear to be actually absent from both the outer channel and the main area, the most conspicuous are the Echinoderms and the Cephalopod[2] molluscs. Certain other divisions of the latter phylum, *e.g.*, the Pteropoda, seem also to be unrepresented in the fauna, as is the case with several groups of coelenterates, notably the Cubomedusae and the stony corals. The aquatic insects are naturally represented by but a few of those families which possess aquatic larvae.

Apart from such limitations, there are also others dependent on mechanical difficulties in collecting. Our collections from the main area of the lake, considering the multitude of individuals and the paucity of forms, are probably almost complete; a few rare species may have escaped our notice, but it is doubtful whether this is the case with the common animals, which are, of course, very much more important from a faunistic point of view. If any of the latter are missing it is probably among the fish that gaps occur. In the fauna of the outer channel on the other hand there are probably many gaps both in the vertebrates and in the invertebrates. All

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[1] *Rec. Ind. Mus., ined.*

[2] Goodrich (*Trans. Linn. Soc., Zool.* (2) VII, pp. 5, 7, 1896) records specimens of *Sepiella inermis* (van Hasselt) and *Loligo indica*, Pfeffer, from the "Chilka Bight", but they were probably obtained outside the mouth of the lake, as they are from the 'Investigator' collections.

the evidence available points to the fact of there being a large number of species in both divisions of the animal kingdom which occasionally enter this part of the lake from the sea in the salt-water season, and it would not be unreasonable to expect to find in the channel at that season stray individuals of any member of the littoral fauna of the adjacent parts of the Bay of Bengal.

The shallowness of the water on the bar at Mugger-Mukh and in the northern part of the main area generally makes it impossible for any but a small boat to enter the outer channel or to proceed much north of Nalbano between October and August, and consequently we were unable to make use, except in September, of our larger nets either in the channel or in the shallows of the northern region. A considerable number of the marine species found in the former part of the lake in September but not in March probably escaped our notice in spring for this reason, and it is also probable that our series of fish and possibly of reptiles would have been considerably augmented if we had had the use of the launch between Satpara and the mouth of the lake at all seasons. The freshwater season (roughly the middle of August to the middle of October) is, however, the critical period in the study of those animals that are able to withstand great changes in salinity and September is therefore perhaps the most interesting month in the year so far as the outer channel is concerned. There is, moreover, no reason to postulate any great difference between the faunas of the northern and central parts of the main area, except in so far as extreme shallowness of water is indirectly destructive of animal life owing to increased temperature. So far as the main area is concerned, the only faunistic boundary that we are able to distinguish extends from Kalidai Id. towards Parikudh.

In our own papers we have included notes on and descriptions of species allied to those from the Chilka Lake but found in the Gangetic delta or in lagoons on the Indian coasts, in cases in which this course seemed desirable.

ACKNOWLEDGMENTS.

In the first place we have to thank both the specialists abroad who are helping us in the preparation of this report and our colleagues in Calcutta who have assisted us in the field and in the laboratory. The artists of the Museum and of the Marine Survey of India, Babus A. C. Chowdhury, S. C. Mondul and D. N. Bagchi, have devoted their usual skill to the preparation of the plates and figures that illustrate our papers, while Mr. G. M. Henry of the Colombo Museum has prepared several sketches of living animals that have been of great use in describing the species. To our assistant in the field, Mr. R. Hodgart, much of the success of our collecting is due. Mr. C. Dodsworth, agent for the Kallikota estates, helped us considerably at Rambha and elsewhere, and we have to thank the Superintending Engineer, Orissa Circle, and the Inspector of Salt Revenue at Satpara for the use of bungalows or boats on the lake. Last but not least of our obligations are those to Colonel Sir S. G. Burrard, F.R.S., and other officers of the Survey of India, who gave us invaluable technical advice and placed at our disposal the scientific instruments that rendered the necessary physical observations possible.

Plate II.


S
A
Saliapali
Trunk Road
Kalupara Ghat Ry. St.
Kankarkuda
LKA LAKE
Dayanaddi
Mugger-Mukh
Poradihi
Tua
Barnikuda
Noapara
SERUANADDI
Bhawanipur
Satpara
Mahosa
Arupatna
Barhampur
Chipakuda
Mirzapur
Manikpatna
Arakhkuda
SANDHILLS
Ruins
MOUTH OF THE
CHILKA LAKE
GAL

A. Chowdhary, del.

FAUNA OF THE CHILKA LAKE

SPONGES.

By N. ANNANDALE, *D.Sc.*, *F.A.S.B.*

(Plates III–V.)

CONTENTS.

SPONGES.

By N. ANNANDALE.

The sponges of the Chilka Lake, though few in number of species, are of great biological interest, not merely because they consist of both freshwater and marine forms growing together in an intimate manner, but also because at least one of the latter has become modified in accordance with conditions of life more proper to an inland lake than to any part of the sea, while the true freshwater sponge *Spongilla alba* has developed peculiarities that are correlated with conditions only to be described as marine. The following is a list of the species obtained in the course of our survey. All are siliceous sponges belonging to the order Tetraxonida.

MONAXONELLIDA.

Fam. SPONGILLIDAE.
Spongilla alba, Carter.
Spongilla nana, sp. nov.

Fam. CLIONIDAE.
Cliona vastifica, Hancock.

Fam. SUBERITIDAE.
Suberites sericeus, Thiele.
Laxosuberites aquae-dulcioris, Annandale.
Laxosuberites lacustris, sp. nov.

TETRAXONELLIDA.

Fam. TETILLIDAE.
Tetilla dactyloidea (Carter) var. *lingua*, nov.

With the exception of *Spongilla nana*, these seven sponges are common either throughout or in parts of the lake. *Spongilla alba*, being apparently unable to live in water that is distinctly brackish or salt at all seasons of the year, is found only in the outer channel and in the northern part of the main area of the lake itself, but flourishes in a pool of fresh water on an island in the southern part. *Spongilla nana* was found, on one occasion only, in the northern part of the same area; it is possibly no more than a modified form of the other species. The boring sponge *Cliona vastifica* is abundant in oyster-shells in the outer channel and also occurs in those of *Purpura* in Rambha Bay and the neighbourhood. *Suberites sericeus* and *Laxosuberites aquae-dulcioris* grow all over the lake, while *L. lacustris* has been found only in rocky localities in the main area, and the *Tetilla* in sandy parts of the outer channel.

We know at present, as I have recently pointed out elsewhere,[1] very little about the littoral sponges of the Bay of Bengal, and the biological conditions that prevail

[1] *Rec. Ind. Mus.* X, p. 194 (1914).

on the coast north of Palk Straits differ greatly from those occurring in the Gulf of Manaar, whence several large collections have been described. It is not surprising, therefore, that the Chilka sponges cast little light on the distribution of the Indian sponge-fauna as a whole. Of the two Spongillidae one is apparently endemic in the lake, while the other has been found in Egypt as well as in different parts of India. The species belonging to marine families also are for the most part either endemic or of wide distribution. To the latter category belong *Cliona vastifica*, which is cosmopolitan, and *Suberites sericeus*, an Indo-Pacific species originally described from Japan and not as yet found in any intermediate locality. *Tetilla dactyloidea*, of which the variety *lingua* is apparently endemic, is known from the Arabian Sea and from the Mergui Archipelago on the east side of the Bay of Bengal. Both species of *Laxosuberites*, so far as their distribution is at present known, are confined to lagoons on the east coast of India and it is not improbable that *L. lacustris* may have been evolved from *L. aquae-dulcioris* in the Chilka Lake.

The main interest of these sponges is, as I have already indicated, of a strictly biological nature. Attention may be drawn in the first place to the remarkable variations exhibited by most of the species and to the fact that these can be definitely correlated with differences in environment. It is evident that all the species in the list are able to withstand, by one means or another, great changes of salinity. The peculiar modification of the simple gemmule characteristic of the Suberitidae whereby *Laxosuberites lacustris* has fitted itself to survive periodical desiccation (p. 50) is a noteworthy instance of adaptation to environment—a series of phenomena also illustrated to a degree hardly less striking by the manner in which the skeleton of *Spongilla alba* is modified to withstand the violence of the waves in exposed positions in the lake (p. 28).

The only sponge not included in the Chilka fauna with which I am acquainted from other Indian lagoons or estuaries is a minute representative of the order Myxospongida found in October, 1913 on oyster-shells in the backwater at Ennur a few miles north of Madras. It accompanied *Laxosuberites aquae-dulcioris*, to young examples of which it bore so close a resemblance in the field that I failed to distinguish the two species. Specimens were therefore preserved without any special care and are so shrivelled and distorted that I can only say in reference to them that they seem to represent an undescribed genus. I failed to find this sponge again at Ennur in January, 1915.

The table on the opposite page shows at a glance the distribution, in the Chilka Lake and elsewhere, of the different species. The names of those that are apparently endemic are marked with a star.

For particulars as to the biological conditions that prevail in different parts of the Chilka Lake at different seasons reference may be made to the Introduction to this volume. The specific gravities of water quoted in the paper are not readings obtained in the field but have been corrected to a standard temperature of 15°C.

GEOGRAPHICAL LIST OF SPECIES.

m.a. = main area : o.ch. = outer channel : sp. gr. = specific gravity of water.

	Chilka Lake.		Further distribution.	sp. gr.
	m.a.	o.ch.		
MONAXONELLIDA.				
SPONGILLIDAE.				
Spongilla alba .. .	X	X	India ; Egypt (*fresh and brackish water*)	1·000—1·0065
*Spongilla nana**	X	..	...	*ca.* 1·006
CLIONIDAE.				
Cliona vastifica	X	X	Cosmopolitan (*marine*) ..	1·000—1·0265
SUBERITIDAE.				
Suberites sericeus	X	X	Japan (*marine*)	1·000—1·0145
Laxosuberites aquae-dulcioris ..	X	X	Madras (*brackish water*) ..	1·000—1·0265
*Laxosuberites lacustris** ..	X	..	...	1·000—1·0150
TETRAXONELLIDA.				
TETILLIDAE.				
Tetilla dactyloidea var. *lingua**	..	X	Typical form in Arabian Sea and off Mergui (*marine*) ..	1·000

Suborder SIGMATOMONAXONELLIDA.

Family *SPONGILLIDAE.*

Genus **SPONGILLA**, Lamarck.

Subgenus **Euspongilla**, Vejdovsky.

Spongilla alba, Carter.

(Plate iii ; plate iv, figs. 1, 2 ; plate v, fig. 1.)

1849. *Spongilla alba*, Carter, *J. Bomb. Asiat. Soc.* III, p. 32, pl. i, fig. 4.
1849. ,, ,, *id.*, *Ann. Mag. Nat. Hist.* (2) IV, p. 83, pl. iii, fig 4.
1863. ,, ,, Bowerbank, *Proc. Zool. Soc.*, p. 463, pl. xxxviii, fig. 15.
1863. ,, *cerebellata*, *id.*, *ibid.*, p. 465, pl. xxxviii, fig. 16.
1881. ,, *alba* var. *cerebellata*, and Carter, *Ann. Mag. Nat. Hist.* (5) VII, p. 83.
1895. ,, *cerebellata*, Weltner, *Arch. Naturg.* LXI (i), p. 117.
1899. ,, *alba*, Petr, *Rozp. Ceske Ak. Praze* II, pl. i, figs. 3-6.
1906. ,, *lacustris* var. *bengalensis*, Annandale, *Journ. Asiat. Soc. Bengal*, p. 56.
1907. ,, *cerebellata*, Kirkpatrick, *Ann. Mag. Nat. Hist.* (7) XX, p. 523.
1907. ,, *alba*, Annandale, *Rec. Ind. Mus.* I, p. 388, pl. xiv, fig. 2.

1907. *Spongilla alba* var. *marina*, *id.*, *ibid.*, p. 389.
1909. ,, *travancorica*, *id.*, *op. cit.*, III, p. 101, pl. xii, fig. 1.
1911. ,, *alba* var. *cerebellata* and var. *bengalensis*, Annandale. *Faun. Brit. Ind.*, *Freshw. Sponges*, etc., pp. 76, 77, fig. 8*b* (p. 71), pl. i, figs. 1-3.
1911 ,, *travancorica*, *id.*, *ibid.*, p. 81, fig. 11.
1913 ,, *lacustris* var. *cerebellata*, Susswasserschwämme in *Wiss. Ergebn. Deutsch Zentralafrika-Exped.* 1907-1908, Zool. 11, p. 475.

The characters usually employed in distinguishing the species of *Spongilla* completely break down in separating *S. alba* from *S. lacustris*. Nevertheless, I believe them to be distinct, for the following reasons:—

1 Even when *S. alba* is growing side by side with green forms of *S. lacustris*, as is sometimes the case, its cells never contain chlorophyl-corpuscles (cells of the alga *Chlorella*).

2. In the living sponge, even when it is fully expanded and in full activity, the oscula are not protected by conical dermal collars, but can be partly or completely closed by horizontal or oblique membranous diaphragms, as in *S.* (*Eunapius*) *carteri*.

3. The oscula are not surrounded by radiating exhalent canals of small width and running immediately below the dermal membrane; single canals similarly situated but of much greater size often open into them after running along the surface for a considerable distance.

4. The main exhalent canals in the interior of the sponge are of much greater calibre than in *S. lacustris*.

5. There is a much thicker horny membrane at the base of the sponge.

6. There is often a subsidiary skeleton in *S. alba*, consisting of single macroscleres fastened together to form a dense irregular network by a secretion of chitinoid substance.

The fact that these characters are for the most part difficult or impossible to recognize in ordinary preserved specimens does not invalidate them from a theoretical point of view, although it renders them inconvenient to the systematist.

There are other distinguishing characters that can usually be applied to individual specimens even when these are not in particularly good condition, but they are not constant and both species are of extreme variability in accordance with environment, locality and individual idiosyncracy. The most notable of the usually differential characters exists in the structure of the skeleton.

In the typical form of *S. lacustris* (*i.e.* the form usually found in normal circumstances in Northern Europe) the radiating or vertical spicule-fibres are compact though slender, and often run for some distance without branching. The spicules of which they are mainly formed are cemented together by a secretion of horny substance, which does not, however, form a sheath on the surface of the fibre. These fibres are joined together, often at considerable intervals, by more slender

transverse ones or even by single spicules: at places there is also an irregular network of single spicules or very fine fibres. At all points at which spicules of the skeleton meet one another at an angle there is a more profuse secretion of horny subtance, which there forms a kind of veil[1] often produced for some little distance along the surface of individual spicules.

In the typical form of *S. alba* (*i.e.* the form represented by the type specimen, which is from fresh water on the island of Bombay) the structure of the skeleton is essentially the same, but the radiating fibres branch and anastomose more freely and the transverse ones are more numerous, so that a closer and harder network is formed. Moreover, the subsidiary skeleton of single spicules to which I have alluded already is characteristic, in its full development, of the harder phases of this species, although but slight traces of it can be detected in the more fragile forms thereof.

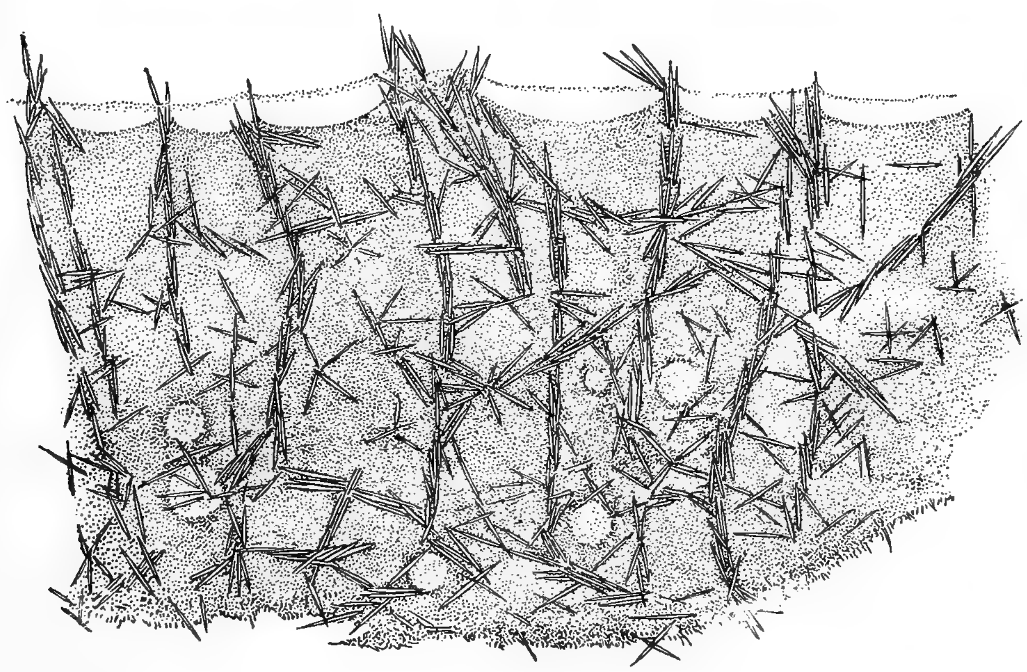

FIG. 1.—*Spongilla alba*, Carter.
Vertical section of a moderately hard sponge from Pigeon Id. in the Chilka Lake, × 30.

If a long series of specimens from different localities be examined it will be found that some of them agree in skeletal structure almost precisely with the typical *S. lacustris*. In the Chilka Lake and its immediate vicinity we obtained specimens not only providing a complete transition, but even going further in some cases than the typical *S. lacustris* in the direction of simplicity of skeleton, and, in other cases, than the typical *S. alba* in that of complexity. In simple forms the secretion of horny matter is much reduced and it does not produce veil-like films at the nodes of the skeleton (see pl. iv, figs. 1, 2, and pl. v, fig. 1).

Neither the spicules nor the gemmules afford any constant differential character. The macroscleres are simple, sharply pointed, smooth amphioxi, very variable in size

[1] Apparently this veil is never deposited in distinct concentric layers as in *Lubomirskia*, *cf.* Annandale, *Rec. Ind. Mus.* X, p. 144, pl. ix, fig. 1*a* (1914).

and proportions in the case of both species, but not essentially different from those of many other sponges. The free microscleres, although also variable, are identical or practically identical in the two species. The microscleres of the gemmule of all forms of *S. alba* with which I am acquainted differ from those of the typical form of *S. lacustris* in being relatively more slender and in never having a very strong curvature, but both these features are found in some forms of *S. lacustris* also, *e.g.* in the common Indian varieties *reticulata* and *proliferens*.[1] The number of free microscleres present is extremely variable. Sometimes they are practically absent from the choanosome. The spicules of a specimen of moderate hardness are figured, on p. 3.

The number of spicules present in and on the pneumatic coat of the gemmule —in some forms of *S. lacustris* both spicules and coat are practically absent—is extremely variable; their precise arrangement is correlated with their number and with the thickness of the coat, another variable character.

In the synonymy given above I have included the names of four varieties (the typical form, vars. *cerebellata, marina* and *bengalensis*) and of a "species" (*S. travancorica*) that I formerly regarded as distinct. Although "typical" (*i.e.* extreme) specimens of these can be readily distinguished, so many intermediate sponges occur that any attempt to distinguish them consistently is vexatious and unprofitable. The form *travancorica* is perhaps more strongly differentiated than the others, but the original description of it was founded on a single degenerate specimen and many of those from the Chilka Lake approach it closely.

Among the latter are included the types of the var. *marina*: also many sponges that are even further removed from the typical *S. lacustris* than is the type of *S. alba*, as well as others clearly referable to the typical form of the latter, to *bengalensis* or, identical, except in the features noted above, with some forms of *S. lacustris*. Others, again, are much harder than the forms of either species hitherto described. The spicules and skeleton of an average specimen are figured in figs. 1 and 2, pp. 27, 30.

Variation in the structure of the skeleton is definitely correlated, in sponges from the lake, with environment. Generally speaking, those that grow on rocks exposed to the violence of waves in open water are hard, their skeleton-fibres being thick, branching and anastomosing freely and containing much horny matter, while the subsidiary skeleton is well developed; those that grow among loose filamentous algae have remarkably slender fibres forming a very open network and containing very little horny matter (compare figs. 1, 1*a* with fig. 2 on pl. iv). In such sponges the subsidiary skeleton is practically absent.

But intermediate forms occur. The softest specimens of the species I have seen anywhere were growing among loose weeds in a small pool of practically fresh water on Barkuda Id.; sponges from rocks in the same pool were much harder, though not as hard as those from similar positions in the lake.

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[1] The tubular form of foraminal armature characteristic of *S. proliferens* is not constant and the sponge cannot therefore be regarded any longer as a distinct species.

The species may be described as essentially an encrusting sponge, but short branches, as a rule distinctly compressed rather than cylindrical, often arise from the surface. Sometimes they are so thin as to be almost filamentous, often they are short and stout and of irregular, triangular or trilobed cross-section (pl. v, fig. 1). In most cases these branches (pl. iii) are mere crusts enclosing fine filaments of algae or the stems of water plants, but sometimes it is not possible to detect in them any extraneous core.

In the phase that occurs on rocks in the Chilka Lake the larger waterways have a distinctly radial arrangement and the main exhalent channels converge, near and on the surface of the parenchyma, to a central primitive osculum. The external surface has a reticulate appearance owing to the arrangement of the skeleton and the meshes are often distinctly longer in the direction of the exhalent channels than in any other. The inhalent channels are vertical in direction and are conspicuous in the dried sponge as circular pits extending downwards from the surface. The dermal pores are scattered and very minute. They have the unicellular structure characteristic of the family.

S. alba has been found in fresh water at several widely separated localities in India: the island of Bombay, the Western Ghats, Calcutta, and Hyderabad: also near Cairo in Lower Egypt; nowhere does it appear to be of common occurrence in ordinary ponds and lakes. It is, however, extremely abundant in brackish water in the Gangetic delta and has been found in the same medium on the west coast of India in the backwaters of Cochin. In the Chilka Lake its distribution is somewhat remarkable It occurs on all the rocks of the northern region, often growing luxuriantly and covering considerable areas, and is found among loose algae in the outer channel. In sheltered inlets among the rocks its gemmules often form a scum on the surface. South of Kalidai Id it is not present in the lake, although many rocks apparently suited for its growth are situated round Rambha Bay. It does grow, however, in a small pool of practically fresh water on Barkuda Id. Even on Kalidai, on the north side of which it is common, we did not find it on the south side. A very careful search at low water on Maludaikuda Id. failed to reveal a single specimen, and no gemmules could be detected on the surface of the water. The sponge evidently flourishes best at depths of from 2 to 10 feet. We found it growing actively and producing larvae in water of a sp. gr. of 1·0065, but it cannot exist in water that never becomes fresh or practically fresh ; specimens taken in salt water in the outer channel were all dead.

The larvae are of the true Spongillid type and resemble those of *S. lacustris* in their ovoid shape.

The colour of *S. alba* varies greatly but depends on external circumstances. As its name indicates, the sponge is, when growing in clean water, of a glistening white very characteristic in its purity, but if the water it inhabits is muddy, as is usually the case, it assumes the hue of the surrounding soil. In the pond on Barkuda Id., where the earth and rocks contain much iron, it is reddish; in the lake and in the creeks and canals of the Gangetic delta it is grey, but this tint is usually concealed

by a dull green flush sometimes so strong as to predominate. In these cases the colour is due to nothing inherent in the sponge but either to minute particles of silt in its parenchyma cells or to the growth in its substance of green filamentous algae, which belong to several quite distinct groups. In the Chilka Lake a chain-forming diatom is often responsible for the green tint.

In its power of engulfing particles of silt without apparent detriment to itself this sponge shows itself peculiarly adapted for existence in muddy water in which the solid particles are extremely small, as is the case both in the lake and in most other places at which it has been found. The minuteness of its dermal pores[1] doubtless serves a similar purpose, or at any rate saves it from being overwhelmed

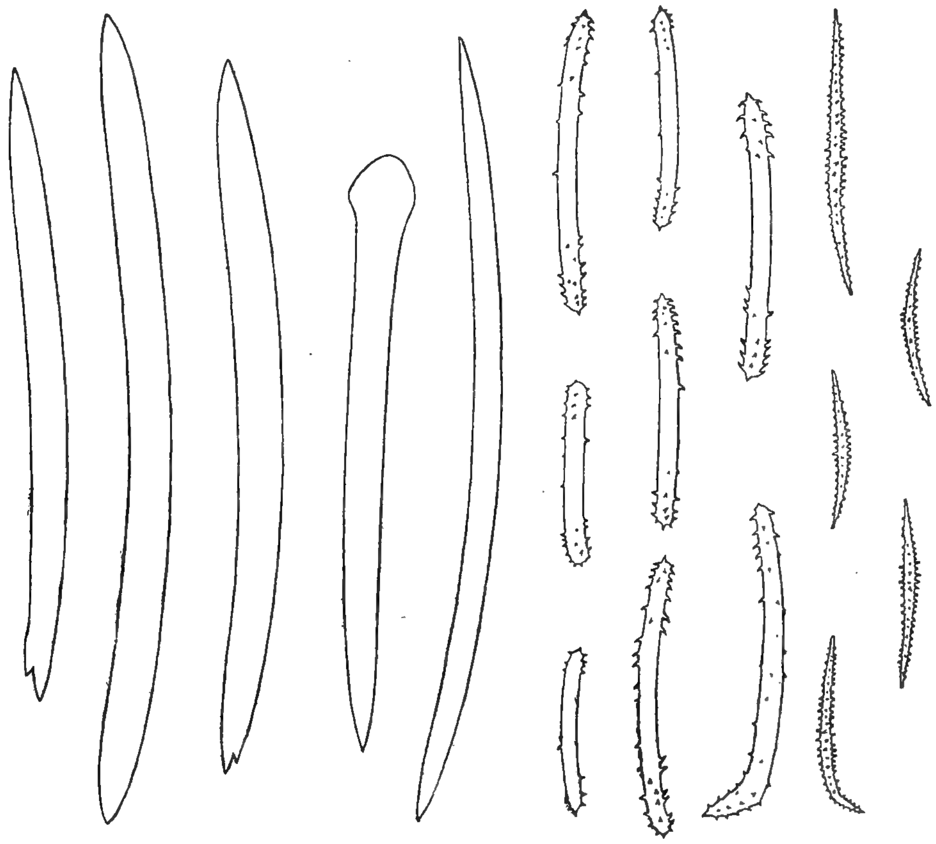

FIG. 2.—*Spongilla alba*, Carter.
Spicules of a normal specimen from the Chilka Lake, × 255.

by the deposition of silt. The green algae that grow in it are parasitic, or at any rate incidentally destructive.[2]

Where rocks occur *S. alba* is literally attracted to them, for as the gemmules are set free from the sponge by the gradual disintegration of its skeleton, they gravitate towards the rocks on the same principle that floating bodies of all kinds are attracted one to another or to fixed objects. Their liberation takes place, owing to the decay of the sponge and the disintegration of the skeleton on the death of its cells, mainly between February and June, but may occur at any time of the year,

[1] These pores have been actually observed, so far as *S. lacustris* is concerned, only in the var, *proliferens*. See *Journ. As. Soc. Bengal* (n. s.) IX, p. 69, pl. v, fig. 1 (1913).

[2] See *Faun. Brit. Ind., Freshw. Sponges*, etc., p. 49 (1911).

and many of them are retained *in situ*, for the skeleton is rarely destroyed completely ere the return of the waters. In the pond on Barkuda Id. only dead sponges were found in April; in July the gemmules were beginning to sprout, and in September the sponges were in full activity, new gemmules being formed. A mass of sprouting gemmules kept in a dish of water on the island in July produced in five days a small sponge with a single osculum. It is worthy of note that they did not each produce a different "individual", but built, as it were, a single edifice in common. The sponge is in full vigour in the lake in November and continues in this condition until the rocks on which it grows become dry or the water round them grows foul owing to the decay of vegetation. As late as the beginning of March some extremely

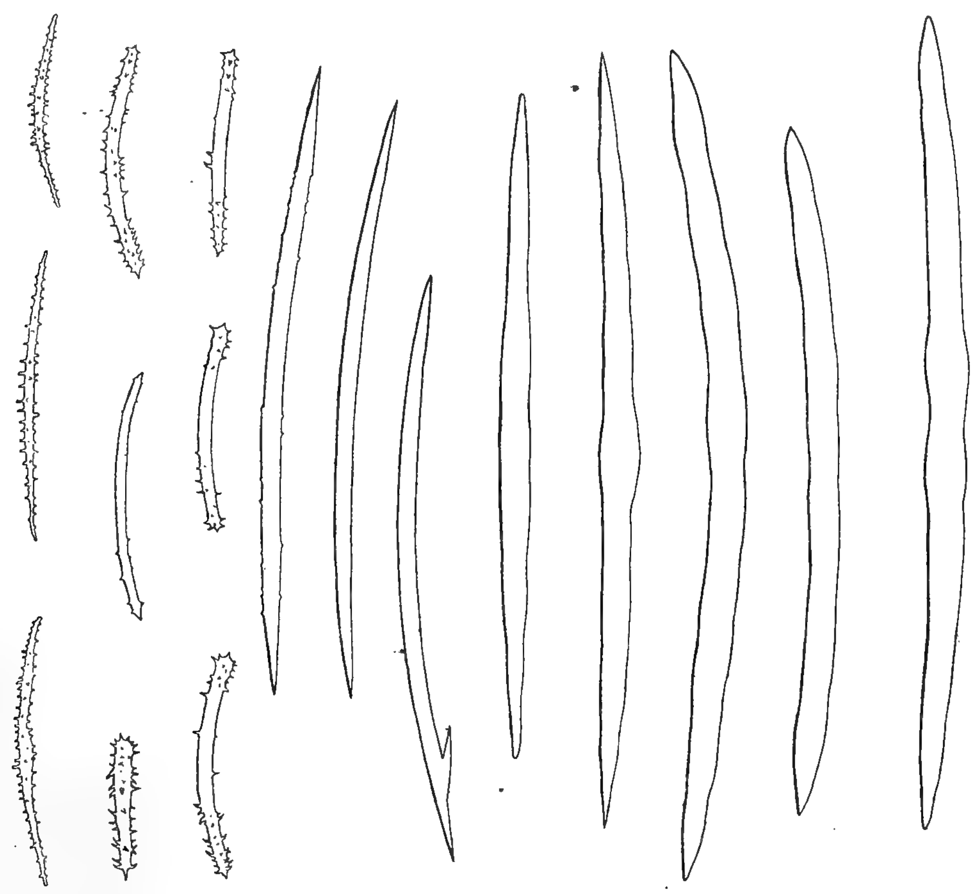

FIG. 3.—*Spongilla nana*, sp. nov.
Spicules of one of the type-specimens, × 255.

hard living specimens were obtained on a little rock out in the lake near Patsahanipur. The water was free from decaying weeds and covered a considerable depth of rock. The earliest date at which we saw sponges of the species in a vigorous condition was the end of September; a large specimen was obtained a few days before the end of that month on a reed at Nalbano Id. in 1913. The sponges taken in March (in water of a specific gravity sometimes as high as 1·0065) contained many mature embryos and young larvae as well as gemmules. The two kinds of reproductive body were evidently produced in close proximity.

The canals of *S. alba*[1] often give shelter to large numbers of small animals of

[1] *Faun. Brit. Ind., Freshw. Sponges* p. 76 (1911).

various kinds, but this is not so commonly the case in the Chilka Lake as in some other localities. We found in them, however, at least two species of Nematode worms (*Dorylaimus* sp. and *Oncholaimus chilkensis*, Stewart[1]) as well as Polychaeta of the family Nereidae. Molluscs of the genus *Modiola* are often overwhelmed by the growth of the sponge, but we did not find in sponges from the lake the shells of *Corbula*[2] so common in those from the ponds at Port Canning.

One of the most striking illustrations of admixture of marine and freshwater fauna that the lake provides is the occurrence on the same rocks, and often even intermingled, of *Spongilla alba* and a sponge of the marine family Suberitidae (*Laxosuberites lacustris*, p. 49 *postea*). When they come in contact the Spongillid, being the more vigorous species of the two, usually overwhelms the other.

Spongilla nana, sp. nov.

(Plate iv, fig. 3.)

The sponge forms spherical or cushion-shaped masses that do not exceed and indeed rarely reach 5 mm. in diameter. The colour (in life as in spirit) is pale yellowish or buff. The whole structure is extremely fragile. There is as a rule a single osculum and in some specimens a cylindrical central cavity can be detected, extending downwards almost to the base of the sponge (pl. iv, fig 3). The subdermal cavity is ample and the general arrangement of the canals and apertures resembles that found in *Spongilla alba*. There is little or no horny matter at the base of the sponge, which is attached lightly to its support.

The skeleton has a distinctly radial arrangement, but contains very little horny matter. The radial spicule-fibres are distinct but slender and feebly coherent. They can frequently be traced from a point near the centre of the sponge to its surface, where they project as spines. The transverse fibres are, however, imperfectly differentiated and in many places represented merely by an irregular network of single spicules. No distinct subsidiary skeleton can be detected.

The spicules in many respects resemble those of *S. alba*, but are as a rule more attenuated and irregular. The macroscleres in particular are remarkable in the latter respect. Some are sparsely and minutely spiny, but their irregularity of outline, the precise nature of which is best indicated by a figure (fig. 3, p. 31), is often of a more general nature. The spicules of this type are sharply pointed at both ends and as a rule slightly and regularly curved.

The gemmule-spicules are slender and also exhibit a slight and regular curvature. As a rule they are distinctly mucronate at both extremities, but sometimes one end is blunt. They bear short, straight, sharp spines, which are fairly numerous at and near the extremities and sometimes a little retroverted in this region. The middle of the shaft is often bare or has only a few isolated spines.

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[1] *Rec. Ind. Mus.* X, pp. 245, 247 (1914).

[2] See Preston, *Ann. Mag. Nat. Hist.* (7) XIX, p. 215 (1907) and Annandale, *Faun. Brit. Ind., Freshw. Sponges*, etc., p. 78 (1911).

The free microscleres are slender, spindle-shaped, sharply pointed, slightly curved amphioxi, covered fairly uniformly with short, straight, blunt spines. They are numerous both in the parenchyma and in the dermal membrane.

The gemmules, though the sponge is never bulky enough to contain many of them, are fully formed and relatively large. They possess a thick pneumatic coat including many spicules. The single foramen is armed with a horny cup or short tubule. The spicules are for the most part tangential to the inner coat but a large number stand upright or nearly upright, giving the surface an irregular appearance like that of the gemmules of the form of *S. alba* that I called *travancorica.* There are also a few horizontal spicules on the surface.

Diameter of gemmule	0.27	mm.
Length of macrosclere (average)	0·192	,,
Thickness ,, ,, ...	0·010	,,
Length of gemmule-spicule (average)	0·098	,,
Thickness ,, ,, ,, ...	0·005	,,
Length of free microscleres (average)	0·0102	,,
Thickness ,, ,, ,, ...	0·001	,,

Type. No. Z.E.V. 6455/7 *Ind. Mus.*

Locality. In a small bay at the base of Patsahanipur promontory, Chilka Lake, Orissa, 26-i-14. Salinity of water approximately 1·006: depth not more than 2 feet.

We found this sponge on one occasion only, but then in considerable numbers. The little spheres or cushions were attached to the free stems of a water-plant. As they were in a small backwater behind a rock where there was much decaying vegetation, I was at first inclined to regard them merely as abortive or abnormal individuals of *S. alba* which, owing to unfavourable conditions, had developed prematurely. This view would be supported by the fact that in general structure they resemble a little sponge from an aquarium in Calcutta that I regard as an abortive form of *S.* (*Eunapius*) *carteri*.[1] Although, however, the skeleton-spicules of young sponges of *S. carteri* are often irregular in outline, this feature is by no means strongly marked in the abortive sponge. Both in it and in some forms of *S. lacustris* that have been found growing in unfavourable environments the gemmules are poorly developed, being not only small but devoid or practically devoid of special microscleres; this is also the case in large sponges of *S. carteri* induced by confinement in an aquarium to produce gemmules prematurely. It is, therefore, an important point in considering the status of *S. nana* that its gemmules are fully developed and relatively large: it is clear that the sponge, in the case of the type-specimens, has produced the gemmules and not the gemmules the sponge, for their surface shows no signs of wear or of having been exposed unprotected to the water and many of them were actually in the course of formation when killed, the outer part of their coat not

[1] *Faun. Brit. Ind., Freshw. Sponges,* etc., p. 126, etc., pl. i, fig. 4 (1911).

being as yet complete. It is mainly this consideration that has induced me to describe the species as distinct, but no other sponge in the subgenus has skeleton-spicules of quite the same nature.

Suborder ASTROMONAXONELLIDA.

Family *CLIONIDAE.*

Genus **CLIONA,** Grant.

1888. *Cliona,* Topsent, *Arch. Zool. expérim.* (2) V *bis,* p. 76.
1891. ,, *id., ibid.,* (2) IX, p. 556.
1915. ,, Annandale, *Rec. Ind. Mus.* XI, p. 1.

Elsewhere I have given a key to the Indian species of the genus (1915, p. 5).

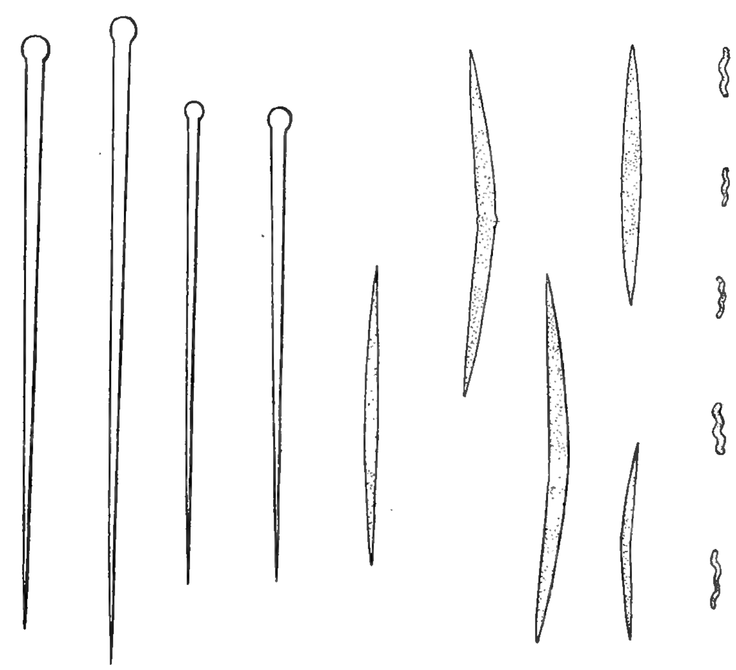

FIG. 4.—*Cliona vastifica,* Hancock.
Spicules of a specimen from the oyster-beds at Manikpatna.

Cliona vastifica, Hancock.

(Plate iv, fig. 7.)

1900. *Cliona vastifica,* Topsent, *Arch. Zool. expérim.* (3) VIII, p. 56, pl. ii, figs. 3—9.
1915. *Cliona vastifica,* Annandale, *Rec. Ind. Mus.* XI, p. 8.

A full description and synonomy of this well-known species will be found in Topsent's paper of 1900. I give here (fig. 4) a figure of the spicules of a specimen from the outer channel of the Chilka Lake.

As I have recently pointed out (1915, p. 8) *C. vastifica* is the commonest species of boring sponge on the coasts of India in quite shallow water; it is cosmopolitan in its distribution. In the Bay of Bengal it is very abundant; apparently it does great injury to oysters and similar bivalve molluscs both there and in the Persian Gulf. In the seas of France it is, according to Topsent, less vigorous than *C. celata,* Grant;

but this is not the case in Indian waters. I figure on plate iv a fragment of an oyster-shell from Manikpatna destroyed by it.

In the Chilka Lake *C. vastifica* is abundant in the oyster-beds of the outer channel. We found it in a flourishing condition both in September, 1913, when the water was fresh or practically so, and in March, 1914, when it was as salt as that of the Bay of Bengal (sp. gr. 1·0265). In the main area, towards the south end of the lake, we took a few shells in which it occurred in February, March, and November in water of a sp. gr. of from 1·006 to 1·010. In the outer channel it was always obtained in the shells of *Ostrea*, in which it was also found in the Ennur backwater and the Adyar river near Madras in October, 1913; whereas in the main area of the Chilka Lake it was only seen alive in shells of *Purpura* (*Thais*) *carinifera*. In the latter region, however, burrows that agree with those made by it in oyster-shells elsewhere were noticed in dead shells of *Placuna* and *Ostrea*.

At both seasons of the year at which we took this species in the outer channel its burrows contained many gemmules as well as living sponge-tissue, and were numerous and of a relatively large size; but examples found in shells of *Purpura* in and in the neighbourhood of Rambha Bay contained few gemmules and were otherwise feeble, though their spicules were well-developed and typical. Curiously enough, *C. vastifica* shares with a deep-sea species of its genus (*C. annulifera*, Annandale[1]) the power of producing gemmules. Their utility is, I believe, in both cases connected with the fact that the shells in which the sponge makes its excavations are liable to be invaded by other boring sponges or covered over by species of encrusting or parasitic habits. We found numerous examples of *Laxosuberites aquaedulcioris* on the outside of oyster-shells whose substance was permeated by the galleries of *C. vastifica*. Where the Suberitid was very thin the excavator maintained itself alive and thrust its papillae right through the substance of the encrusting form, but this became impossible as the latter grew thicker and the hidden sponge was soon overwhelmed. Encrusting sponges that coat small areas such as the external surface of shells cannot be long-lived and it is not improbable that the gemmules lie concealed in the interior of the shell when their parent-sponge is overwhelmed, and sprout *in situ* if favourable conditions return.

Family *SUBERITIDAE*.

Genus **SUBERITES**, Nardo.

1900. *Suberites*, Topsent, *Arch. Zool. expérim.* (3) VIII, p. 224.

The genus *Suberites* as now restricted consists of massive sponges with a confused skeleton, without detachable ectosome, but with vertical bunches of spicules on the surface. Although a considerable number of Indian species were assigned to it in days when the name had a much wider significance, only three that have hitherto been recorded from Indian seas can now be assigned to the genus: *Suberites*

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[1] *Rec. Ind. Mus.* XI, p. 12, pl. i, fig. 2 (1915).

carnosus (Johnston),[1] *S. inconstans*, Dendy[2] and *S. cruciatus* of the same author.[3] The first of these is a cosmopolitan species found by Carter in the late Dr. J. Anderson's collection from the Mergui Archipelago: the two latter were described by Prof. Dendy from Mr. E. Thurston's and Prof. Herdman's collections from the Gulf of Manaar. Thiele[4] states that *S. inconstans* is a *Spirastrella*, but I have not succeeded in finding the characteristic microscleres of that genus in specimens from the Gulf of Manaar; possibly the sponges from Celebes examined by Thiele represented a distinct species. Carter's *Suberites vestigium*,[5] an example of which was recently obtained by Mr. S. W. Kemp at Kilakarai on the Gulf of Manaar, is a *Pseudosuberites*.

One species of *Suberites* (*s.s*) is well represented in our collection of the Chilka fauna, namely *S. sericeus*, Thiele, a very distinct form that shows a relationship in one of its phases to *Pseudosuberites*, though better developed sponges clearly belong to the parent-genus of the family. This species was originally described from Japan.

Suberites sericeus, Thiele.

(Plate iv, fig. 4.)

1898. *Suberites sericeus*, Thiele, Stud. ü. pacif. Spongien (*Bibl. Zool.* X, 24), p. 39, pl. viii, fig. 10.

Thiele's species was described from two small specimens that had grown on the shells of Gastropods. Apart from his account of the spicules, of which he gave a good figure, the description was by no means full and all that we learn from it is that the specimens, which were dry, formed thin films of small size and that the skeleton of one was amorphous while that of the other was "somewhat reticulate." Fortunately the spicules are characteristic. Although all are macroscleres and tylostyles, they may be separated into two classes, the more distinctive of which is remarkable for its short, stout form (fig. 5).

In the Chilka Lake this sponge is found in two phases, one of which is apparently identical with that of the type-specimens, while the other is much more robust. The former may be called phase A, the latter phase B.

In phase A the sponge is restricted in area, forms a film not more than 2 mm. thick and has a minutely hispid but otherwise smooth surface; whereas in phase B it extends over areas of considerable extent, may attain a depth of at least 50 mm., and is not only hispid on the surface but also produces irregular projections and, occasionally, curious ear-like horizontal outgrowths.

The two phases are not absolutely distinct, for the extreme periphery of large masses of sponge closely resemble phase A and when masses of the kind grow out

[1] Most fully described by Topsent in the paper cited (1900), p. 233.

[2] *Ann. Mag. Nat. Hist.* (5) XX, p. 154, pls. ix, x (1887).

[3] In Herdman's *Ceylon Pearl Fisheries* III, p. 131, pl. v, fig. 10.

[4] Stud. ü. Pacifisch. Spongien (*Bibl. Zool.* X, 24), p. 10, pl. i, figs. 3, 3*a*, pl. v, fig. 4 (1899).

[5] *Ann. Mag. Nat. Hist.* (5) VI, p. 52, pl. v, fig. 21 (1880).

over leaves that come in contact with them or the shells of mussels attached to the same support, the thin film that they first produce over these bodies, before incorporating them, is indistinguishable from the less robust phase. The differences between the skeletons of the two phases are no less striking than those between their external forms, and just as in *Laxosuberites aquae-dulcioris* one phase of the species approaches the genus *Prosuberites* in certain details of structure (p. 43 *postea*), so

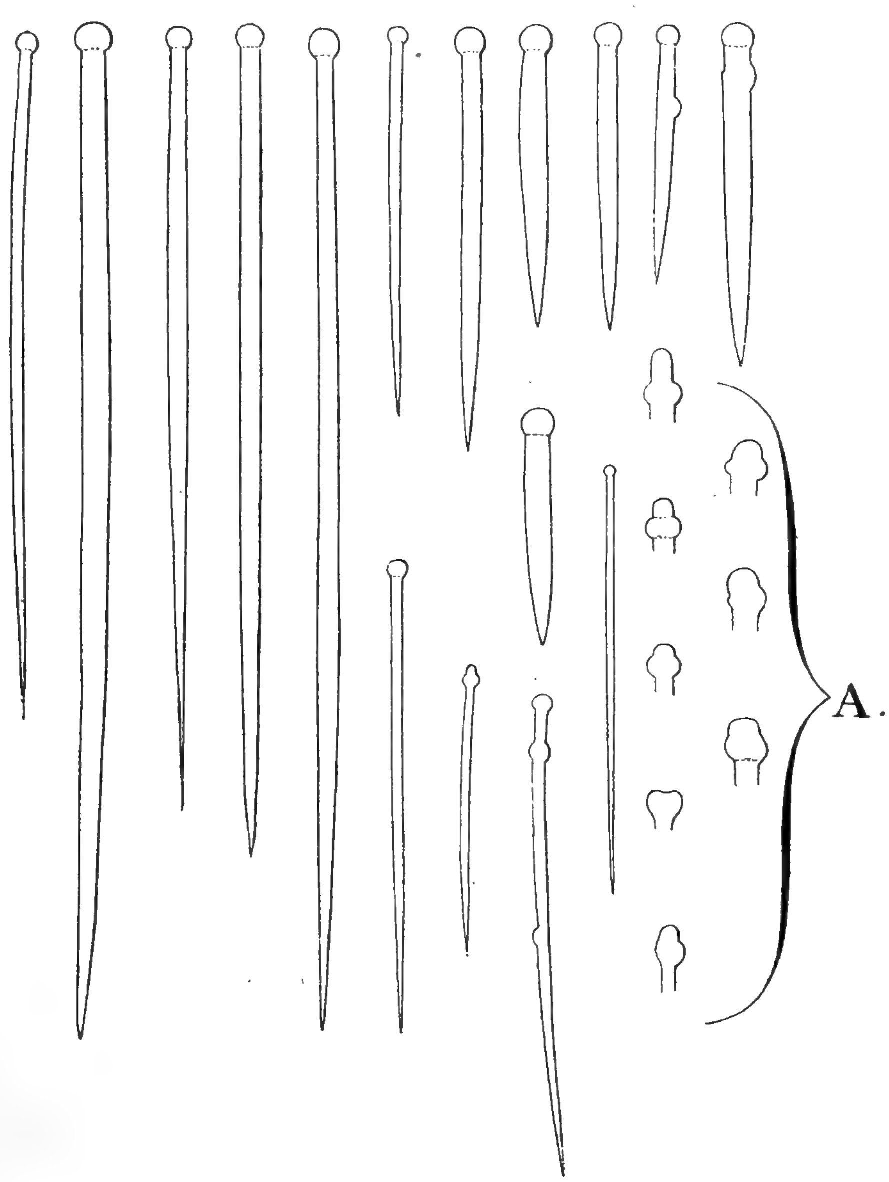


FIG. 5.—*Suberites sericeus*, Thiele.
Spicules of a specimen in phase B, × 255.
A.—Heads of spicules further enlarged.

in *Suberites sericeus* one phase, in this case as in that of the other species the less robust, approaches the genus *Pseudosuberites*.

Before discussing the peculiarities of the two phases in detail it will be as well to say something of the specific characters.

The most constant of these is the occurrence both of short, relatively stout spicules and of much larger ones in which the shaft is relatively more slender.

Those of the larger type have small subglobular heads which are not separated from the shaft by a constriction. As a rule the heads are only prevented from being spherical by the fact that they are flattened at the point at which they are attached to the shaft, but trilobed, acorn-shaped and other forms occur among them (fig. 5) and these are often asymmetrical. The shafts are long, relatively slender and as a rule straight, if curved but slightly so and usually only towards the distal extremity. The maximum diameter is already attained at the point at which they are joined to the head and does not diminish until near the other end, at which the shaft tapers to a very fine point. The greatest length of the spicules of this type is 0·44 mm., the greatest thickness of the shaft 0·0117 mm. and the diameter of the head about 0·0126 mm. Some spicules that belong on account of the relative slenderness of their shafts to the same type are rather smaller and a few greatly so, being not more than 0·105 mm. long. The diameter of the shaft varies considerably.

The second type of spicule has the shaft as stout as that of the largest spicules, but the maximum diameter is situated as a rule near the middle of the length and the shaft tapers towards the head. The length of the shortest spicules of this type is not more than 0·098 mm., but it may be as much as 0·147 mm. and is usually about 0·12 mm.

Spicules of the first type are found in abundance throughout the sponge, but those of the second occur singly in the central parts only.

The living sponge, in both phases, is of a bright sulphur-yellow colour, which is evenly distributed throughout its substance and disappears rapidly in spirit. The consistency is soft and somewhat elastic.

The oscula are small and scattered; they are not connected, as in the two species of *Laxosuberites* found in the lake, with a regular system of subdermal canals, but a few irregular exhalent channels in this position sometimes open into them. As a rule these canals are more deeply buried, often running for some distance parallel to the surface in the choanosome and opening not directly into the osculum but into vertical canals that extend downwards from it. The pores are minute and not confined to restricted areas; the vertical lacunae into which they open are small and the structure of the whole inhalent system is obscure.

The position of the main exhalent channels, combined with the rather dense structure of the outer parts of the sponge, indicates some approach to the differentiation between ectosome and choanosome that reaches a much higher degree of development in *Pseudosuberites*. There are always, moreover, horizontal spicules in the external parts, though this is much more marked in certain conditions of the sponge than in others and in some cases their number is very small.

There is a stout horny membrane at the base of the sponge.

Phase A.

The skeleton in this phase is fragile and the exercise of pressure immediately reduces it to an amorphous state. If sections be made of carefully preserved material a definite structure is apparent, especially if the part sectioned does not contain

gemmules. In those parts of the sponge in which reproductive bodies are absent, numerous spicules will be found with their heads embedded in the basal membrane and their points projecting upwards. In most cases they do so at an angle less than a right angle, but regular ascending columns of an entirely non-plumose character can be distinguished. The lowest spicules in these columns project straight upwards from the basal membrane, while the highest form brushes on the surface of the sponge, where they are to some extent splayed out.

Otherwise the skeleton forms an indefinite network in which the strands are formed mainly of single spicules and no very distinct fasciculation can be detected. On and near the surface there are numerous horizontal spicules.

Where gemmules are present the lower part of the skeleton becomes partially or wholly disorganized, while the spicules tend to be massed in a horizontal layer a little below the surface. As the cellular parts of the sponge also degenerate on the

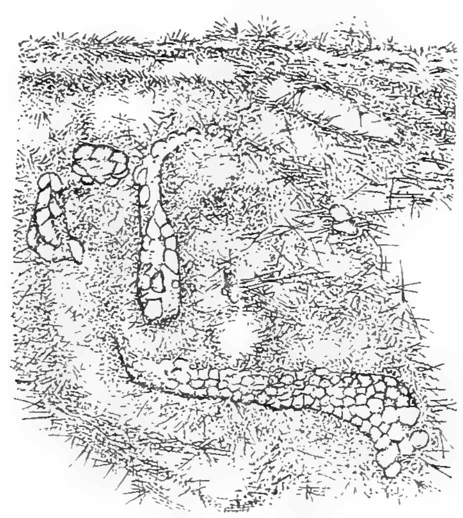


FIG. 6.—*Suberites sericeus*, Thiele.
Vertical section through the outer part of a sponge in phase B, showing gemmules, × *ca.* 10.

production of gemmules and are less completely destroyed where furthest from these bodies, the flesh is also massed together above and an "ectosome" distinct from the choanosome is thus formed (fig. 7, p. 40).

Gemmules are produced in large numbers. They form a single layer at the base of the sponge firmly connected with the adherent basal membrane. They vary greatly in size and shape but are always flattened at the base and strongly convex above. Their horny coat is thin, but the fact that it is deposited in several layers can sometimes be ascertained from its laminated structure. There is no foramen (micropyle). The structure of the actual reproductive body is that usually found in the gemmules of sponges. Spicules do not as a rule penetrate the gemmule-coat.

Phase B.

The skeleton in this phase is much more complex (fig. 4, pl. iv). The spicules that have their heads embedded in the basal membrane form a dense irregular mass, all or practically all of them meeting the membrane at an angle less than a right angle.

Only obscure traces of vertical fasciculation can be detected in the basal parts immediately above this mass, but on the surface of the sponge the vertical tufts of spicules so characteristic of several genera of Suberitidae are well developed. They arise directly from vertical, entirely non-plumose columns in which all the spicules point directly upwards and which can be traced downwards to different levels in the sponge, some of them for at least one-third of its depth. The section figured on pl. iv passes through the outer wall of a large horizontal canal probably belonging to the exhalent system and it will be readily seen that the spicules here lie horizontally parallel to one another. Had the section passed outside the canal altogether no such horizontal stratum would have been shown, and had it passed through the lumen instead of the wall there would of course have been a longitudinal gap. In the former case it would have been possible to trace the vertical columns much further down, and they would have merged gradually into the confused intermediate zone of the skeleton instead of being sharply divided from it by a horizontal layer.

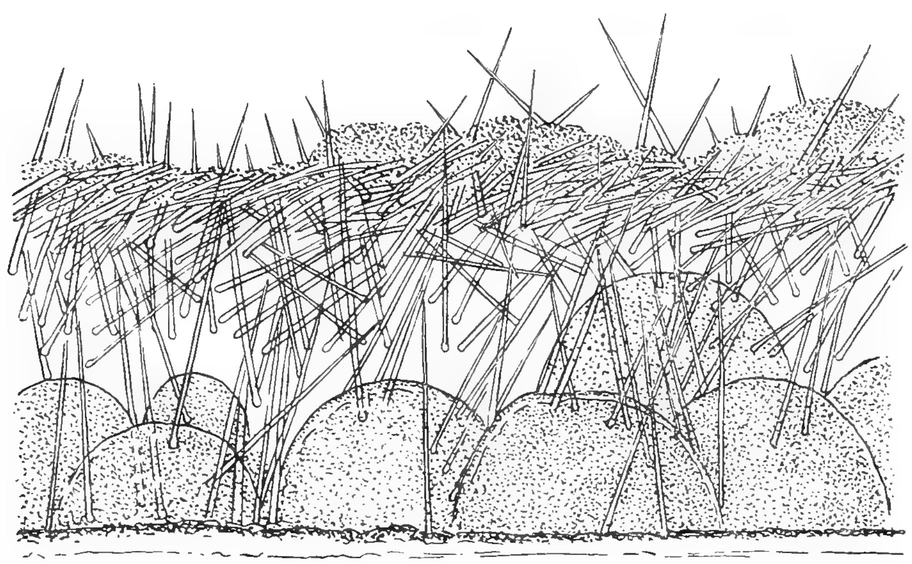


FIG. 7.—*Suberites sericeus*, Thiele.
Vertical section through a sponge in phase A with gemmules, × 150.

If fragments of this confused intermediate layer be removed from the sponge they will be found to be surprisingly coherent; it is even possible to macerate the flesh from them and preserve them intact. The explanation lies in the fact that many of the spicules are cemented together in slender and often irregular fascicles by a scanty but strong secretion of transparent horny substance and that both the fascicles and single spicules not included in them are fastened to one another in a similar manner at the points at which they impinge. This is particularly noteworthy in the neighbourhood of foreign bodies such as the stems of Hydrozoa (*Bimeria*) that lie buried in the sponge. The heads of many spicules are embedded in a horny secretion covering such bodies in exactly the same manner as at the base of the sponge and these spicules seem to form as it were a nucleus from which the reticulation of the skeleton arises (pl. iv, fig. 4*a*).

Gemmules are developed abundantly. Individually they resemble those found in the other phase of the species, but they form, instead of a flat basal layer, serpentine masses (fig. 6, p. 39) that meander through the sponge-like veins of mineral in a rock. Each of these masses has in its centre some foreign body such as a filament of alga or a branch of *Bimeria* and there is no essential difference in the two phases except that the gemmules in phase B are attached to foreign bodies of the kind instead of to the basal membrane.

Suberites sericeus was described from Kagoshima in Japan and has not hitherto been recorded, so far as I am aware, from any other locality. In the Chilka Lake we found it both in the outer channel and in the main area. In the latter we discovered accidentally that the bottom of the 'Lady of Chilka', which then lay off Barkuda Id., was coated with masses of the sponge in its more robust phase. This was in July, 1914. In the outer channel specimens of the less robust form were taken in September, 1914, at four stations, in all cases in very small quantities.

The sp. gr. of the water, which was quite fresh in the outer channel in September, was 1·0145 at Barkuda Id. in July. The depth at which the sponge was collected varied from about 2 feet to about 2 fathoms.

The species seems to stand alone in the genus; from other species the structure of its skeleton, as well as the form of its spicules, separates it. It has no close relationship to the genus *Laxosuberites*, to which Topsent, who had evidently not seen a specimen, proposed to assign it (*op. cit.*, 1900, p. 184).

The phase A was found in the Chilka Lake coating the leaves and stems of *Halophila ovata* and other plants, while in Japan it was taken on the shells of Gastropod molluscs. The phase B has only been found on the bottom of a steam-launch. The small size and feeble development of the former may possibly be connected with the small area to which it was confined, while the circumstances in which the robust sponge was growing, on the only occasion on which it has yet been seen, were perhaps unusually favourable for its growth. The fact that one phase was taken in brackish and the other in fresh water was probably accidental. Gemmules were found in both forms in the circumstances described.

On the 'Lady of Chilka' the sponge had grown over an assemblage of small mussels (*Modiola striatula*) as well as many colonies of the hydroid *Bimeria fluminalis*. Some of the latter seemed to be quite dead, but others were valiantly holding their own and budding out fresh polyps on the surface of the sponge. Of the mussels a few also survived and had succeeded in keeping open, over the tips of their shells, slit-like apertures through which they could obtain food and water. But the majority had perished and been completely buried. In some cases the two valves were found still cohering at the narrow end but forced widely apart at the other and coated inside and out with living sponge. In others the valves were shut or almost so, and the remains of the animal, not yet completely liquified, were still held between them. In yet others the sponge was beginning to force the shells apart at the broad end and to invade their inner surface; the remains of the animal, rendered liquid by putrefaction, were being gradually absorbed. These facts are

interesting as suggesting a reason, or rather as supporting a suggestion already advanced,[1] for the fact that sponges of different kinds frequently grow over molluscs or their eggs[2] and that the shells or egg-cases are found full of sponge-substance.

The case of hydroid colonies buried in sponges is somewhat different. In instances such as the present one their vital parts may serve as food for the sponge, but in others the association is apparently symbiotic and the two organisms afford mutual support the one to the other without suffering in consequence.[3]

Genus **LAXOSUBERITES**, Topsent.

1896. *Laxosuberites*, Topsent, *Mém. Soc. zool. France*, IX, p. 126.

1900. ,, *id.*, *Arch. Zool. expérim.* (3) VIII, p. 184.

Topsent (1900) defines this genus as having the skeleton composed of ascending columns in which the spicules are all orientated in one direction. Neither of the two species found in the Chilka Lake agrees precisely, when fully developed, with this definition, for the spicule-fibres that form the main element in the skeleton are to a large extent horizontal and there are also many non-fasciculated horizontal spicules in the choanosome and basal membrane that may be regarded as a part of the skeleton. However, the peculiarities of these species are obviously correlated with the method of growth and certainly do not justify generic separation from *L. rugosus* (Schmidt), the type-species of the genus. Their relationship to it is discussed on p. 50.

According to Topsent, Schmidt's *Suberites paludum*, which was originally described from a Mediterranean lagoon, is synonymous with *L. rugosus*. The genus is also represented in the fauna of the Black Sea and other enclosed waters and would seem to be one peculiarly capable of adapting itself to life in such situations. A remarkable adaptation of the gemmules of one of the Chilka species is described here (pp. 48, 49).

Laxosuberites aquae-dulcioris (Annandale).

(Plate iv, figs. 5, 6.)

1914. *Suberites aquae-dulcioris*, Annandale, *Rec. Ind. Mus.*, X, p. 157, pl. xi, fig. 1.

I have little to add to the description of this sponge published in 1914, so far as its structure is concerned. Attention may be invited, however, to the peculiar spiral arrangement of the spicules round the broader vertical canals (pl. iv, fig. 6*a*) and to the fact that the sponge occurs in two somewhat distinct phases of growth in accordance with the nature of the surface to which it is attached. When it is growing on an oyster-shell or a stick it is rather more robust and has the skeleton distinctly better developed than when it is attached to the leaves and

[1] Annandale, *Faun. Brit. Ind., Freshw. Sponges*, etc., p. 94 (1911).

[2] Herdman, *Journ. Linn. Soc.* (Zool.) XXXII, p. 271 (1914).

[3] Alcock, *Ann. Mag. Nat. Hist.* (6) X, p. 208 (1892).

slender stems of weeds. In the latter situation it is naturally dwarfed, owing to the limited area to which it is restricted, and its skeleton is so simplified (fig. 9, p. 44) that it resembles that of Topsent's genus *Prosuberites*, which is defined as having all the tylostyles with their heads in contact with the basal membrane and their shafts projecting upwards. At the edges even of sponges of the more vigorous phase a similar arrangement occurs; but, as Dendy[1] has pointed out, the different genera into which the old genus *Suberites* have recently been divided are, in some instances, not very clearly separated one from another. In any case, *L. aquae-dulcioris* is never devoid of horizontal spicules and always, in at least some spicule fibres, some of the spicules are not in contact with the basal membrane.

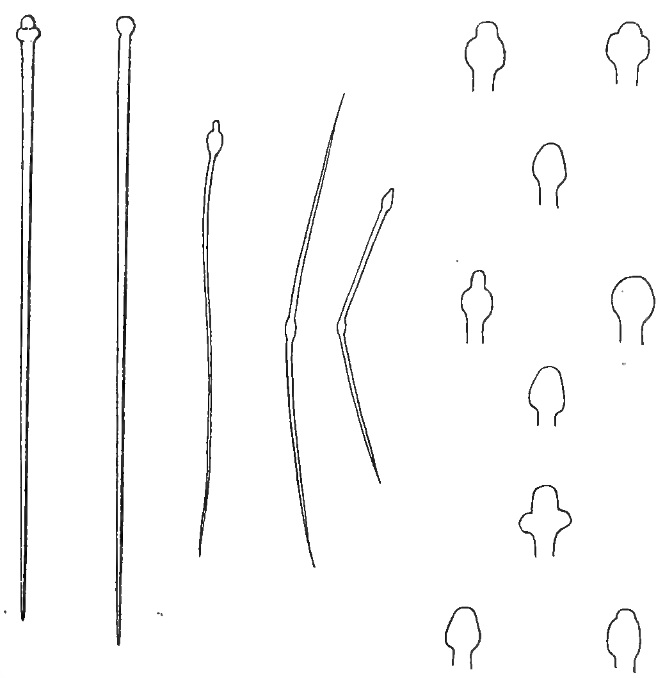


FIG. 8.—*Laxosuberites aquae-dulcioris* (Annandale).
Spicules from type-specimen, × 255.
A.—Heads of spicules further enlarged.

The species is abundant on the oyster-shells of the beds near Manikpatna in the outer channel of the Chilka Lake and has also been found, in its less vigorous phase on the stems and leaves of the plant *Halophila ovata* both in the outer channel and at various places in the neighbourhood of Barkul and Barkuda Id. in the main area. It occurs in water as salt as the Bay of Bengal, of different degrees of salinity and quite fresh, and is found vigorous in all (and at all times of the year) at depths varying from a few inches to 2 fathoms.

Ripe embryos, which closely resemble those of *L. lacustris* (p. 49) in colour, size and external form, were found in a sponge growing on a leaf of *Halophila* at Barkuda Id. in July. Gemmules were seen only in specimens taken in fresh water

[1] In Herdman's *Ceylon Pearl Fisheries*, III, p. 131 (1905)

(both in the outer channel and in the main area) in September, but several sponges from oyster-shells from Manikpatna taken in that month do not contain these bodies. They are only present in specimens on leaves and stalks. Possibly the stimulus necessary for the development of gemmules in this species may be set up by the decay of vegetable matter, but more evidence is necessary before a definite opinion can be expressed. In structure the gemmules differ considerably from those of *L. lacustris* (fig. 11, p. 48) and are hardly distinguishable from those of the less robust phase of *Suberites sericeus* (fig. 7, p. 40), having thin shells without foramina and being arranged in a single adherent layer at the base of the sponge.

L. aquae-dulcioris differs in colour in different circumstances. Often it is hyaline

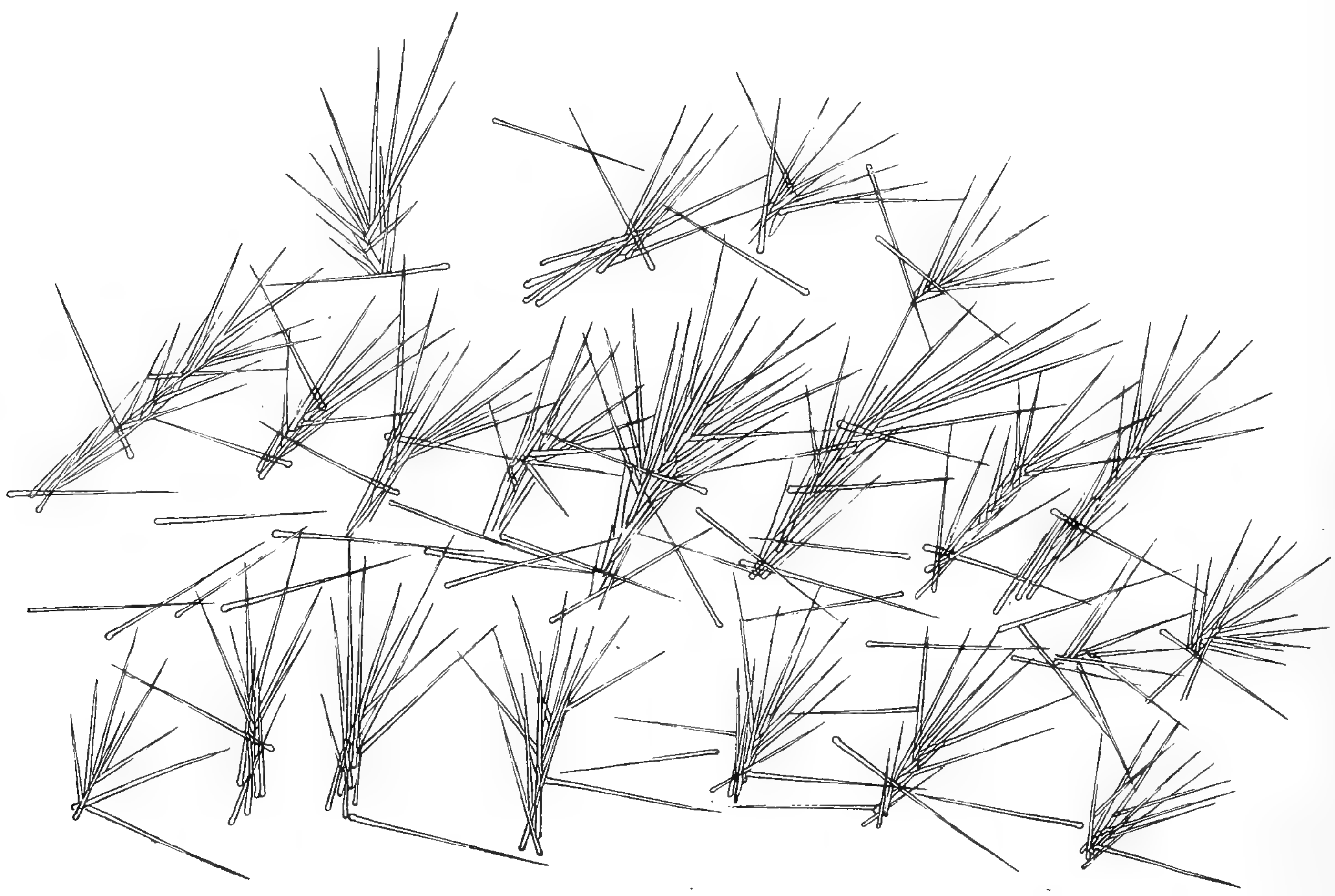


FIG. 9.—*Laxosuberites aquae-dulcioris* (Annandale). Part of the skeleton of a sponge on a leaf of *Halophila*, × 100.

and quite colourless; sometimes it is of a more or less deep orange-yellow, and occasionally bright green. The yellow colour seems to be due, probably in all cases, to the accumulation of food-material in cells that have taken part or are about to take part in the formation of eggs or gemmules, while the green is due to the growth in the substance of the sponge of a branching alga of simple structure, which only grows if the organism is exposed to light. As the sponge usually affects sheltered situations, this is not very often the case.

I will discuss the affinities of this sponge together with those of *L. lacustris* on a subsequent page (p. 50).

Laxosuberites lacustris, sp. nov.

(Plate v, figs. 2, 3).

The sponge forms thin and fragile films, sometimes a little less so than those of *L. aquae-dulcioris*, on stones and rocks. Its colour varies in the same manner and for the same reasons as that of the latter species. In spirit any that may be present (except the yellow of the gemmules, which is remarkably permanent) disappears and the whole specimen assumes a milky opacity. The external surface, except immediately round the gemmules and on the roofs of the superficial canals, is level and minutely hispid These areas are smooth and, in the living sponge, convex.

Probably each sponge possesses only one osculum, but many frequently grow so close together as to form an apparently uniform layer of considerable area. The osculum is slightly raised on a crater-like eminence with gently sloping sides. In the living sponge it is protected by an oscular collar capable of expansion to a considerable length. This structure is a hollow cone formed of dermal membrane without skeletal support. The actual exhalent orifice is situated at its free extremity and is considerably narrower than the base of the cone. When fully expanded the latter is much longer than it is broad at the base, where it is almost equal in width to the main exhalent channel from the roof of which it arises. The external (*i.e.* immediately subdermal) horizontal exhalent channels form a very conspicuous feature in the external appearance of the sponge. Each system of the kind consists of a main channel which runs along the surface of the parenchyma in a straight or sinuous course for a distance of some 5 to 10 mm. The oscular collar arises from its roof at or near the middle. Running into it at fairly regular intervals on either side are lateral channels like itself but narrower; these, in their turn, receive yet other, still narrower channels, so that an entirely horizontal ramification is formed. In the living sponge the roofs of all those channels, that is to say those parts of the dermal membrane that cover them, are markedly convex and quite hyaline. The inhalent dermal pores lie scattered in the intervals between the lateral channels. They are somewhat variable in size, but always minute; the largest I have seen were not more than 0·08 mm. in diameter. In the preserved sponge apertures of both kinds are as a rule obliterated, the oscular collars disappear and the roofs of the exhalent channels collapse. In both living and preserved specimens ridges may frequently be observed on the surface, sometimes marking off enclosed areas. These are, however, due not to any peculiarity in the structure of the sponge, but to the growth in its substance or below its base of algae, of the stolons of a Hydroid (*Bimeria*) or of a Polyzoon (*Loxosomatoides*), or else to the tubes made by a minute Polychaete worm.

The dermal pores open directly, as is so often the case in thin encrusting Monaxon sponges of different families, into cylindrical channels of considerably greater diameter than themselves and running in a vertical direction. The upper part of these channels, which is wider than the lower, represents the subdermal cavity, but the lower part extends nearly to the base of the sponge. Finer afferent channels are given off radially from the lower part of the main ones, run in a horizontal

or inclined plane and, probably after branching at least once, ultimately reach the small, ill-defined lacunae round which the ciliated chambers are arranged. The chambers are oval in outline and about 0·0026 mm. long by 0·002 mm. broad. Fine exhalent channels run from the lacunae and, after combining once or more, reach the superficial canals; their course is naturally upwards in a sloping direction. The soft parts of the sponge may be described as compact in comparison with those of other species of the genus.

The skeleton consists of two distinct parts: plumose spicule-fibres that terminate in free brush-like bunches of spicules on the surface of the sponge, and a basal horny membrane containing isolated spicules, which are as a rule smaller and more slender than those of the fibres.

The spicule-fibres differ but slightly as a rule from the type characteristic of the genus. Sometimes, however, at the extreme margin of growing sponges and in stunted specimens they resemble the simple upright bunches of *Prosuberites*. In those sponges that may be regarded as fully formed and well developed the primary fibres are directed for a short distance vertically upwards from their base, then bend over gradually and run for some distance horizontally (that is to say parallel to the surface of the sponge), and finally protrude upwards. The spicules all point away from the basal extremity of the fibre. Except at the base, I have not been able to detect any binding substance in the fibres, and the extreme readiness with which the whole structure is disorganized by the exercise of pressure would seem to prove that substance of the kind is not more, at most, than very scantily present. The primary fibres terminate in the usual manner in bunches of spicules directed outwards as well as upwards; the tips pierce the dermal membrane. The whole disposition of the skeleton is closely correlated with that of the osculum and exhalent channels, and, indeed, with that of the water-system generally. The direction of the spicules is away from the osculum, so that the fibres they form radiate outwards from it between the main exhalent channels, parallel to which they run. At the margins of these channels the primary fibres give off short lateral branches that have a somewhat fan-like arrangement individually and lie in the dead sponge horizontally and practically parallel to the surface. Those from the primary fibre on either side of the channel nearly meet in its middle. When, however, a current of water passes through towards the osculum it raises these lateral fan-like branches and causes them to arch over immediately under the dermal membrane, to which they give support. The tips of their spicules, which are directed outwards from the primary fibre, do not penetrate it as do those of the spicules which form the terminal brushes. Single spicules lie scattered in a horizontal direction on the floor of the superficial channels.

At the base of the sponge there is a delicate but distinct horny membrane in which, as already stated, spicules usually smaller than those of the fibres lie scattered horizontally. This structure is very liable to be overlooked as it can be separated from the stone to which the sponge is attached only with some difficulty.

All the spicules are normally tylostyles and there are no microscleres. The

tylostyles have a very distinct head, which is variable in shape and may be irregular; it is much more frequently spherical or symmetrically elliptical than in *L. aquae-dulcioris*. The shapes that it may assume in the two species are shown in figures 8 and 10. The shaft is usually straight or slightly and regularly curved. It is always slender and tapers gradually to a sharp point. There is practically no dilation

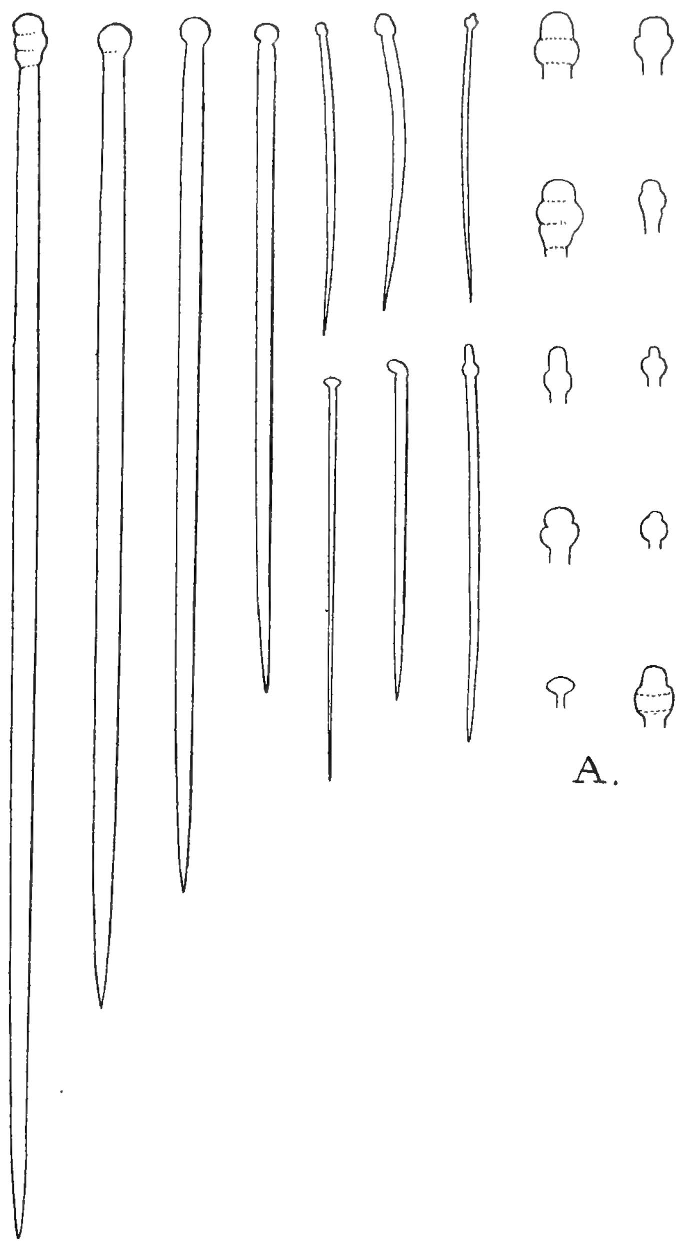


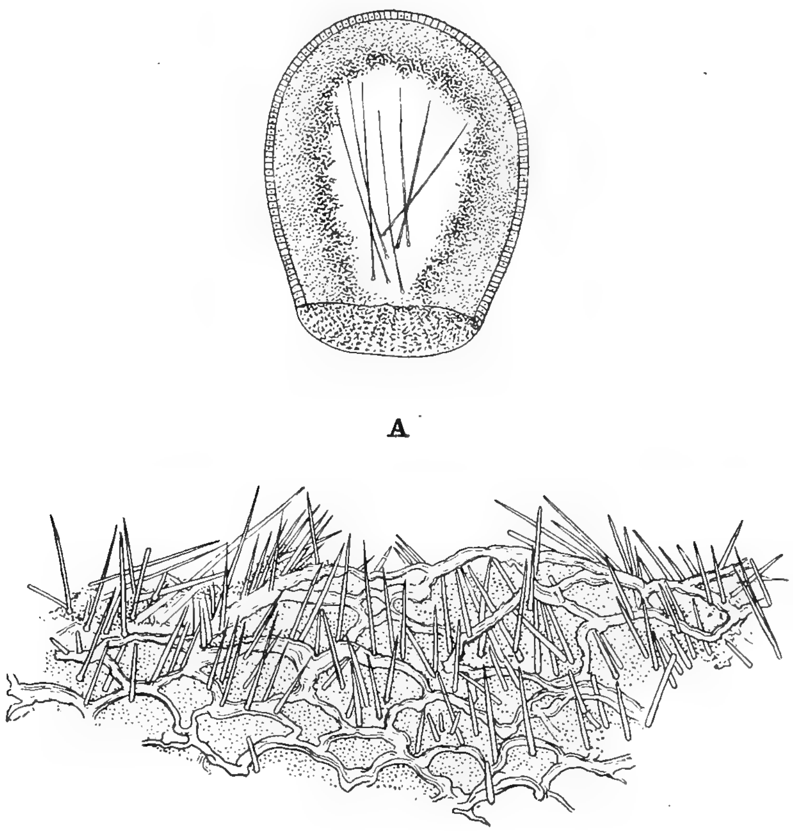
FIG. 10.—*Laxosuberites lacustris*, sp. nov.
Spicules from a typical specimen, × 255.
A.—Heads of spicules further enlarged.

of the axial canal in the head, and this canal is never broad or conspicuous. The length of the largest spicules is 0·56 to 0·58 mm., and the breadth of the thickest part of the shaft 0·008 mm., the corresponding measurements in *L. aquae-dulcioris* being 0·33 mm. and 0·005 mm.[1] In *L. lacustris*, however, some of the shorter-spicules

[1] "0·033" in the original description (*Rec. Ind. Mus.* X, p. 158) is a printer's error. In some specimens the spicules are smaller than in others.

are often actually stouter than those of greatest length. The breadth of the head is slightly greater than that of the shaft. The measurements of the spicules are extremely variable both individually and in different sponges, but some of them are always much larger than any in *L. aquae-dulcioris*.

Gemmules are produced in large numbers. They are formed in groups at the base of the sponge and are visible externally as relatively large patches of lichenoid outline and of a deep orange-yellow colour. The skeleton becomes completely disorganized in these patches and the basal membrane disappears as an independent structure. Each group consists of numerous gemmules piled one on the top of the other several layers thick. The individual gemmules are flattened on the lower surface, distinctly convex above, and polygonal in outline. The whole mass (fig. 11B) is fixed together by spicules of the normal type which transfix the coats of the gemmules vertically or tangentially, their heads being lower than their tips. The actual reproductive body consists of a congeries of cells of the usual form gorged with globules of food-material of a bright yellow colour. It is to this substance that the colour of the whole mass is mainly due, but it is intensified by the tint of the horny coat. Each gemmule has its own coat, but the different gemmules of one patch are so closely pressed together that their coats become intimately connected.



A

B

FIG. 11.—*Laxosuberites lacustris*, sp. nov.
A.—Larva in optical section, × 255.
The cilia are omitted.
B.—Vertical section though a mass of gemmules, × 30.

There is no orifice, but the coat, which is about 0·007 mm. thick, is deposited in several layers, between which there is air or some other contained gas, so that, when dry, the structure has a slight silvery lustre. The gemmules vary in size, but the greatest transverse diameter does not exceed 0·21 mm. The biological significance of the whole structure is discussed below (pp. 51, 52).

The larvae (fig. 11A) is, when set free, a minute ovoid body distinctly truncated at the broader end. Its colour is a uniform clear yellow not quite so deep as that of the gemmules. Cilia cover the whole external surface except the broad truncated end, which forms a hernia of relatively large cells. I have not been able to make a detailed examination of living material, but in well-preserved and stained specimens the cells of the external ciliated epithelium (endoderm) seem to be slightly elongated immediately round the hernia. There is, therefore, reason to think that a ring of longer cilia surrounds this region. The greatest length (in Canada balsam) is about 0·139 mm., and the greatest width about 0·102 mm. A distinct segmentation-cavity of irregular shape and relatively large size can be detected in the interior of the larva anterior to the mass of enlarged cells that forms the (posterior) hernia. A single fascicle of spicules is already present. Although the spicules are very slender, they are clearly tylostyles with a distinct head. Their heads rest, approximately in a ring, a little in front of the enlarged cells; their shafts point forward and a little outwards and lie to a considerable extent in the segmentation-cavity. Their points are separated by a considerable distance from the anterior extremity. The fascicle is composed of about 7 spicules.

Type. No. Z.E.V. 6442/7. *Ind. Mus.*

L. lacustris has been found as yet only in the main area of the Chilka Lake, in which it occurs abundantly, often together with *Spongilla alba*, wherever there are rocks or stones at the edge. It can live, at any rate for a season, in pure fresh water and has not yet been found in that of a greater sp. gr. than 1·0150. It grows at all times of the year, but is most vigorous at the season when the water of the lake is brackish but the level still fairly high (that is to say about December and January), and occurs in depths of from a few inches to at least 2 fathoms.

It is with considerable hesitation that I describe this sponge as a species distinct from *L. aquae-dulcioris*, but on the whole, to do so seems less liable to cause confusion, should my opinion be ultimately proved incorrect, than to regard the sponge, without experimental evidence, as merely a highly specialized phase of that species. The most important differences between the two forms are the following :—

1. The spicule-fibres of *L. lacustris* are longer, branch more freely and maintain a horizontal direction for a greater part of their length than those of *L. aquae-dulcioris*.
2. The spicules are even more variable in size but have spherical or slightly elliptical heads in a great proportion of instances; some of them are always considerably larger than any of those of *L. aquae-dulcioris*.
3. The gemmules are piled together in *L. lacustris*, one on the top of another in

several layers, and are held in this position by vertical spicules which transfix them. Lichenoid coherent masses of gemmules, which can be detached as a whole, are thus formed, instead of a single adherent layer as in *L. aquae-dulcioris*.

In general structure the two sponges resemble *L. rugosus* (Schmidt)[1], except that they are much less vigorous in their growth and that their main exhalent channels and the main component parts of their skeleton exhibit a greater tendency to be horizontal. The two facts are probably correlated. The spicules of both species differ from those of Schmidt's in having the heads practically always differentiated, though often irregular. They are also more variable in size. In these respects they come nearer the spicules of *L. ectyoninus*, Topsent, from which they differ in that by no means all of them are directed "towards the periphery of the body" (Topsent, *op. cit.*, p. 189, pl. vii, figs. 11, 12). As regards the form of the spicules both species agree closely with the variable Australian *L. proteus*, Hentschel[2], but from all varieties of this sponge they are separated by the structure of their skeleton and the general smoothness of their surface.

L. lacustris was always found on stones or rocks except in one instance in which it was on a dead bamboo. On rocks it grows on vertical faces and on the lower surfaces of overhanging projections; on stones it occupies the lower side only, unless the stone is protected by others above it. This seems to be not so much due to avoidance of light as to the fact that its comparatively flat surface renders it liable to be completely smothered by the settling of silt if it spreads out in an exposed position. If sponges of the species are placed alive and surface uppermost in an aquarium full of lake-water they rapidly become covered with fine mud and débris, through which their oscular collars project upwards. The convexity of the roof of the superficial exhalent channels, combined doubtless with the steady movements of the water in the canals, keeps the roofs free of extraneous matter for some time and the plan of the canals is mapped out in a very conspicuous manner by clear hyaline streaks in the general area of mud; but the dermal pores are soon choked, and the sponge dies.

Larvae were found in April ready to be liberated in the canals of sponges which also contained gemmules. Gemmules are produced at all times of the year but particularly at the approach of the hot weather. At this season most of the rocks on which the sponge flourishes are gradually exposed by the retreat of the water. As it dries up it naturally dies. Sponges that suffer thus before producing gemmules, as is not infrequently the case, cling tightly as dried skeletons to the stone, their horizontal fibres being pressed against their adherent basal membrane (pl. v, fig. 2); but no fibres persist in the gemmule-masses and the basal membrane has practically disappeared below them. When these masses are thoroughly dry, therefore, they begin to curl up round the edges owing to the unequal contraction of the

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[1] Topsent, *Arch. Zool. expérim* (3) V, p. 185, pl. v, figs. 1-4.

[2] "Tetraxonida" in Michaelsen and Hartmeyer's *Faun. Südw. Australiens* II, pp. 389, 391 (figs. 20, 21), 392 (figs. 22, 23), pl. xxii, figs. 1-3 (1909).

component parts during desiccation, and are finally detached intact by the wind, which wafts them away and, sooner or later, drops them in many cases, on the surface of the water. There they float. We may imagine that a large number are carried by wind or water to quiet nooks among the rocks where they germinate when the floods return, while others are submerged by heavy rain. The majority of these are probably smothered in the mud at the bottom of the lake, but some may fall on stony ground. The masses are rendered extremely light by the spaces between the different layers of horny substance on the surface of the gemmules[1], and probably some are transported for long distances. The whole mechanism of these structures affords a most interesting example of adaptation on the part of a sponge of recent marine origin, as *L. lacustris* undoubtedly is, to conditions that can rarely, if ever, occur in the sea.

Smaller masses of gemmules of the same constitution as the large ones remain embedded in small cavities on the rock on which they were deposited, and their gemmules germinate *in situ*. This seems to occur mainly at the beginning of the salt-water season, that is to say in November and the beginning of December. At this time of the year I have found many young sponges at different stages of development. In gemmule-masses of the kind, as in the case of *Spongilla alba* (p. 31, *antea*), each mass of gemmules produces a single sponge with one osculum. A number of small sponges often arise from different masses deposited close together on a rock or stone. They do not, however, fuse, when, in the course of growth, they come in contact, but remain distinct, apparently throughout life, although their margins are co-terminous. It is in this way that large areas are often covered with what appears at first sight, but not on careful inspection, to be a uniform layer of sponge.

Another instance of adaptation to environment is probably to be found in the reproduction of this sponge, *viz.* in the large irregular cavity which occupies a considerable proportion of the interior of the larva (fig. 11A). Topsent[2], discussing the structure of the larva in the different families of Halichondrine sponges, points out that a series of lacunae normally occurs in the primitive epiderm of the embryo and regards these as identical, not merely homologous, with the much larger single cavity found in the larva of Spongillidae. He does not, however, notice that in that larva the cavity is not only of much more regular form but is actually lined by a specialized membrane[3] of which there is apparently no trace in marine types. I have commented elsewhere[4] on the essential resemblance of the Spongillid larva,

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[1] Possibly the horny coat of the gemmules of Suberitidae is always deposited in layers; this is clearly the case in *Ficulina* (see Miss Sollas's figure reproduced on p. 230 of Vol. I of the *Cambridge Natural History*). In most cases, however, it is extremely thin, and I can find no reference in literature to spaces between the layers.

[2] *Arch. Zool expérim.* (5) VII, pp. xiii and xiv (1911).

[3] This is clearly shown in a figure recently published by Nöldeke. *Zool. Jahrb.* (*Anat.*) VIII, fig. 1 (1913).

[4] *Journ. As. Soc. Bengal* (n. s.) IX, p. 222 (1913).

in its mechanism and functions, to that of Polyzoa Phylactolaemata and have suggested that in both cases the bladder-like body is an adaptation for life in fresh water. The fresher water is, the lower its specific gravity. The yolk contained in larvae that grow without feeding is heavy, and a body that has to progress through fresh water to obtain a situation suitable for subsequent changes is greatly hindered if it is much heavier than the medium through which it moves. If it is hollow, and if the cavity is filled with water, as that of the larvae under consideration presumably is, the weight of the yolk is compensated for and the specific gravity of the moving body becomes practically identical with that of the surrounding medium. The cavity in the larva of *L. lacustris* is not relatively so large as that in the larvae of *Spongilla*, *Nudospongilla* and *Ephydatia*, nor has it the same specialized structure, but it is at any rate considerably more ample than in most marine types. Its size is, therefore, not improbably correlated with the fact that the larva lives in water of low salinity and consequently of low specific gravity.

L. lacustris is too thin a sponge to afford shelter to any but very small animals. Nematode worms (*Dorylaimus* sp.[1]) are, however, common in its canals; at least one minute species of tubicolous polychaete, probably a Capitellid, was found on one occasion, while another, tubicolous and plumigerous species is nearly always abundant. The rhizomes of the Hydrozoon *Bimeria fluminalis* and the Polyzoon *Loxosomatoides laevis* are also often found at the base of the sponge, sending up their branches or polyps through its substance to the surface. Lamellibranch molluscs of the genus *Modiola* are sometimes overwhelmed in its growth.

Grade **TETRACTINELLIDA**.

Suborder SIGMATOPHORA.

Family *TETILLIDAE*.

Genus **TETILLA**, Schmidt.

[**Tetilla dactyloidea** (Carter).]

1869.	*Tethya dactyloidea*,	Carter,	*Ann. Mag. Nat. Hist.* (4) III, p. 15, fig.
1872.	,,	,,	*id.*, (4) IX, p. 82, pl. x, figs. 1-5.
1887.	,,	,,	*id.*, *Journ. Linn. Soc. Zool.* (Fauna Mergui, I), p. 79.
1888.	*Tetilla*	,,	Sollas, '*Challenger*' *Rep.*, *Zool.* XXV, p. 1.
1891.	,,	,,	Keller, *Zeitschr. wiss. Zool.* LII, p. 335.
1903.	,,	,,	v. Lendenfeld, *Das Tierrech*, Tetraxonia, p. 18.

Distribution: S. Arabia; Bombay; Mergui Archipelago, Burma (*Carter*).

The typical form of *T. dactyloidea* was not obtained in the Chilka Lake, but another, so near that I think it must be regarded as a variety, is represented in our collection by several specimens. For this form I propose the name *lingua* in reference to its peculiar shape.

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[1] Stewart, *Rec. Ind. Mus.* X, p. 247. When Capt. Stewart's paper was written *L. lacustris* was not distinguished from *L. aquae-dulcioris*.

var. **lingua**, nov.

(Plate v, fig. 4).

The var. *lingua* differs from the *forma typica* of the species in the following characters :—

1. The sponge is tongue-shaped and compressed instead of being sausage-shaped.
2. The minute spherical spicules found by Keller in Carter's specimens from Arabia (the types of the species) are absent.
3. The basal tuft of spicules is much reduced, being visible to the naked eye merely as a slight shagginess.
4. The single osculum at the central cavity of the sponge is even smaller, or perhaps capable of more complete contraction.
5. The pores are apparently confined to the upper three quarters of the superficial area of the sponge.

I have been able to compare our specimens with several of those from the Mergui Archipelago examined by Carter. As Sollas has pointed out, the latter do not altogether agree with the original specimens and I cannot find in them, any more than in the types of the new variety, the minute siliceous spheres found by Keller in Carter's Arabian examples.

The sponges from the Chilka Lake agree well in general structure with those from Mergui, from which they differ notably in their compressed, tongue-like shape and in the still greater reduction of the basal tuft. The spicules, except that those of the basal tuft are of course much shorter, appear to be practically identical. The osculum is more completely closed and the central cavity into which it opens almost obliterated. The fact, however, that the external surface is thrown in the larger specimens into strong vertical folds in the anterior part of the body, and the manner in which these folds radiate from the osculum, would indicate that the sponges were killed in a highly contracted state. The shape of the posterior end is somewhat variable, this extremity being tapering and rounded in some sponges and obliquely truncate in others. In the latter there is no trace of external injury. The largest, which has this shape, is 58 mm. long and 22 mm. broad in the middle, where it is 10 mm. thick. This specimen is less compressed in the anterior region than the others. A photograph of it, with one of a smaller example from the same station, is reproduced on plate v, fig. 4. The colour of the sponge (in life and in spirit) is pale greenish grey.

Specimens of *T. dactyloidea* var *lingua* were taken in the outer channel of the Chilka Lake in September, 1914, at depths of about 2 fathoms. All were on a sandy bottom. The water at the time was fresh, but there can be little doubt that the sponge is also to be found at the same place when it is salt. It evidently lived in groups at more than one point.

The species has always been taken in shallow water apparently anchored in sand by its basal tuft. The reduction of this tuft is probably correlated with the compressed form of the new variety, and both characters, as well as the position of the

pores, seem to indicate that it lives more deeply buried than the typical form. Its superficial resemblance to *Sphenopus marsupium*, an Actinian that lives buried in mud and is common off the mouths of the Ganges, is noteworthy and affords an interesting instance of convergence. Dendy[1] has pointed out that *T. dactyloidea* is closely related to the species he described under the name *T. limicola*, except in the important feature that in the latter "the sponge is very compact throughout, and there are no wide tubes in it, the excurrent canals being very narrow and opening by numerous minute apertures in the floor of a somewhat flask-shaped cloacae with slit-like vents on the surface of the sponge." He rightly regards this feature as an adaptive one connected with the fact that the sponge lives in very fine soft mud in Lake Tamblegam, a comparatively small lagoon on the coast of Ceylon that closely resembles the Chilka Lake in many respects. So far as its compact structure and the absence of broad channels go, the Chilka sponge is very like the Tamblegam one, but the nature of its single exhalent aperture is totally different. Although it lives in sand, the water above it is always full of fine silt held in suspension. The case seems to be in some respects parallel to one I have recently discussed elsewhere, *viz.* that of *Corvospongilla barroisi* and *Nudospongilla aster* in the Lake of Tiberias.[2] In both cases we find sponges structurally related and living in the same, or a very similar, environment, but adopting diametrically opposite means of protecting their water-system; in both cases the disadvantages of their environment are due to minutely separated mineral matter held in suspension in the water or settling on the surface of the sponge.

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[1] "Report on the Sponges" in Herdman's *Ceylon Pearl Oyster Fisheries* III, p. 94 (1905).

[2] *Journ. Asiat. Soc. Bengal* (n. s.) IX, p. 76 (1913).

EXPLANATION OF PLATE III.

Spongilla alba, Carter.

A rock at the edge of the Chilka Lake partly covered by the sponge.

The photograph was taken in November after the level of the lake had sunk about 5 feet, leaving the sponge dry. The rock was 2 ft. 11 in. in width and was covered with a somewhat sparse growth of filamentous alga. The sponge had grown over this alga on the lower part of the rock and the apparent branches on its surface were actually thin incrustations of the filaments.

Bemrose, Collo., Derby.

SPONGES OF THE CHILKA LAKE.

EXPLANATION OF PLATE IV.

Figs. 1, 1a, 2. *Spongilla alba*, Carter.

1, 1*a*. Fragments of the skeleton of a very hard specimen from a rock in the Chilka Lake, × 50.

The preparations had been cleaned and stained with pyrogallic acid to show the horny substance. Some of the single spicules forming the subsidiary skeleton may be noted *in situ*.

2. Fragments of the skeleton of a very soft specimen from weeds in a pond on Barkuda Id., treated in the same way, × 50.

Fig. 3. *Spongilla nana*, sp. nov.

A complete sponge stained with borax carmine and mounted in Canada balsam, seen from below, × 15.

c.c.—central cavity. s.c.—subdermal cavity. g.—gemmule.

Figs. 4, 4a. *Suberites sericeus*, Thiele.

4. Vertical section through the skeleton of a sponge in the more vigorous phase, × 15.

4*a*. Fragments of the skeleton from the interior of the same sponge in the neighbourhood of an engulfed colony of the hydroid *Bimeria fluminalis*, more highly magnified. The preparation has been stained with pyrogallic acid.

s.f.—vertical spicule-fibres on the surface of the sponge. i.c.—the position of one of the main horizontal canals. b.m.—horny basal membrane.

Figs. 5, 6, 6*a*. *Laxosuberites aquae-dulcioris* (Annandale).

5. Type-specimen on an oyster-shell from Manikpatna in the outer channel of the Chilka Lake, × 2.

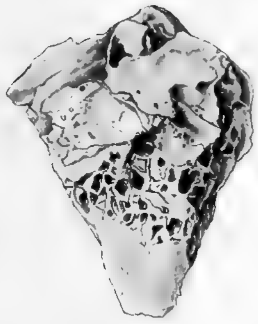
6. A single branched spicule-fibre in lateral view, × 100.

6*a*. A fragment of the skeleton in the neighbourhood of a large vertical and a superficial horizontal canal, × 75.

v.c.—position of vertical canal. h.c.—position of horizontal canal.

Fig. 7. *Cliona vastifica*, Hancock.

Part of an oyster-shell from the Manikpatna beds destroyed by the sponge, × 1.



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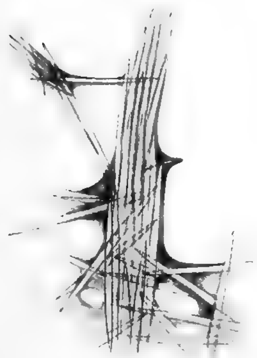
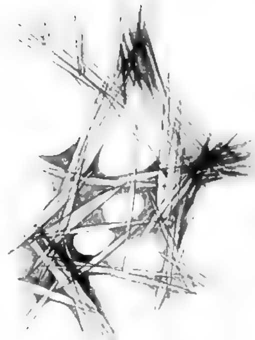
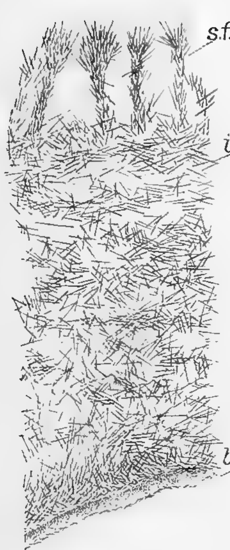


1.



1a.

2.



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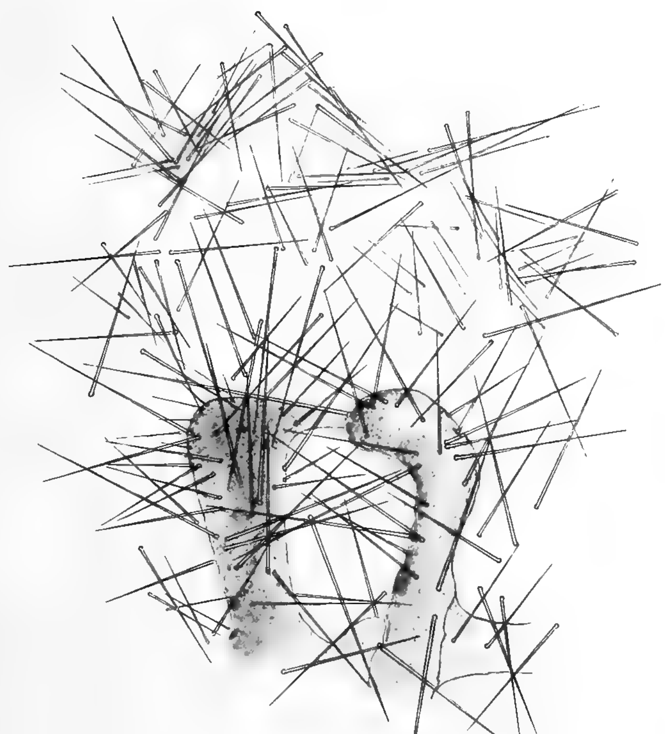
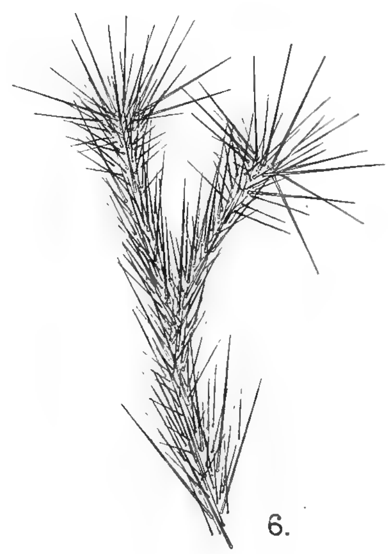


4a.



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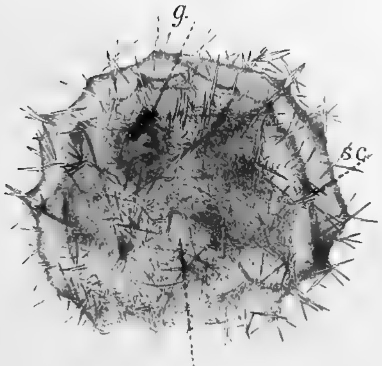


3.

6a.

5.

A.C. Chowdhary, del.

Bemrose, Collo., Derby.

SPONGES OF THE CHILKA LAKE.

EXPLANATION OF PLATE V.

Fig. 1. *Spongilla alba*, Carter.

A thick section through the base of a branch in the neighbourhood of an osculum, × 10.

The soft parts of the sponge have been entirely removed ; the filmy substance shown particularly in the lower lobes of the section is the subsidiary skeleton.

Figs. 2, 3, 3a. *Laxosuberites lacustris*, sp. nov.

2. Dried specimen on a stone, somewhat enlarged.

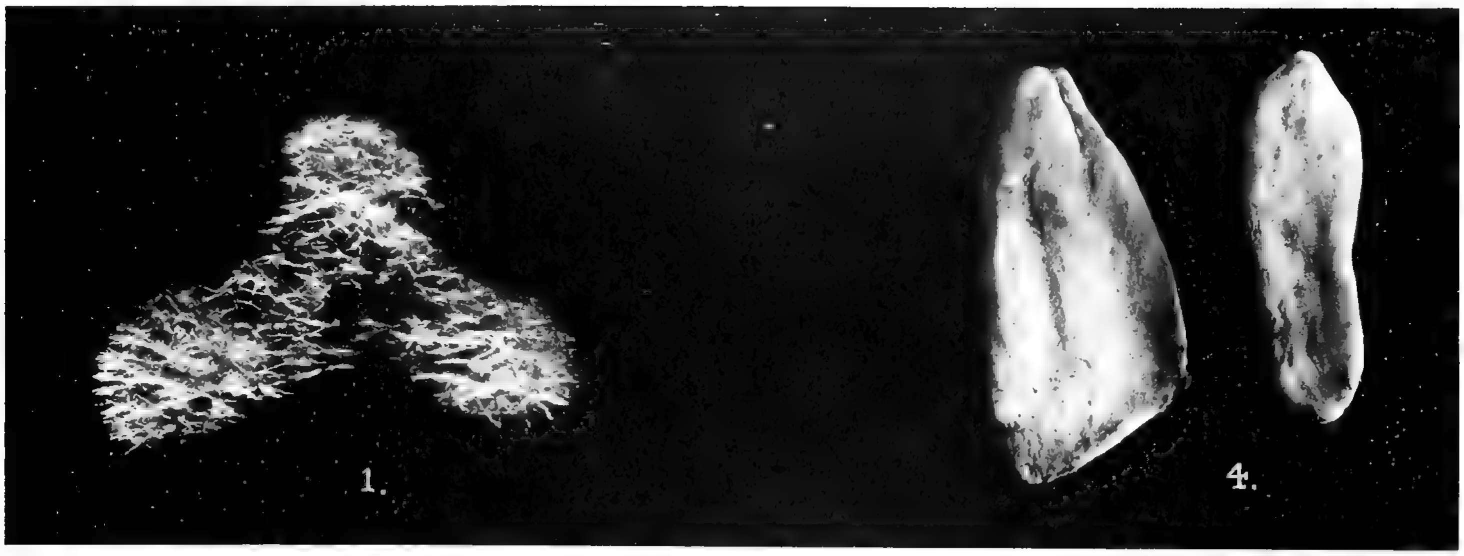
3. Mass of gemmules removed from a rock by the wind, seen from above and considerably enlarged.

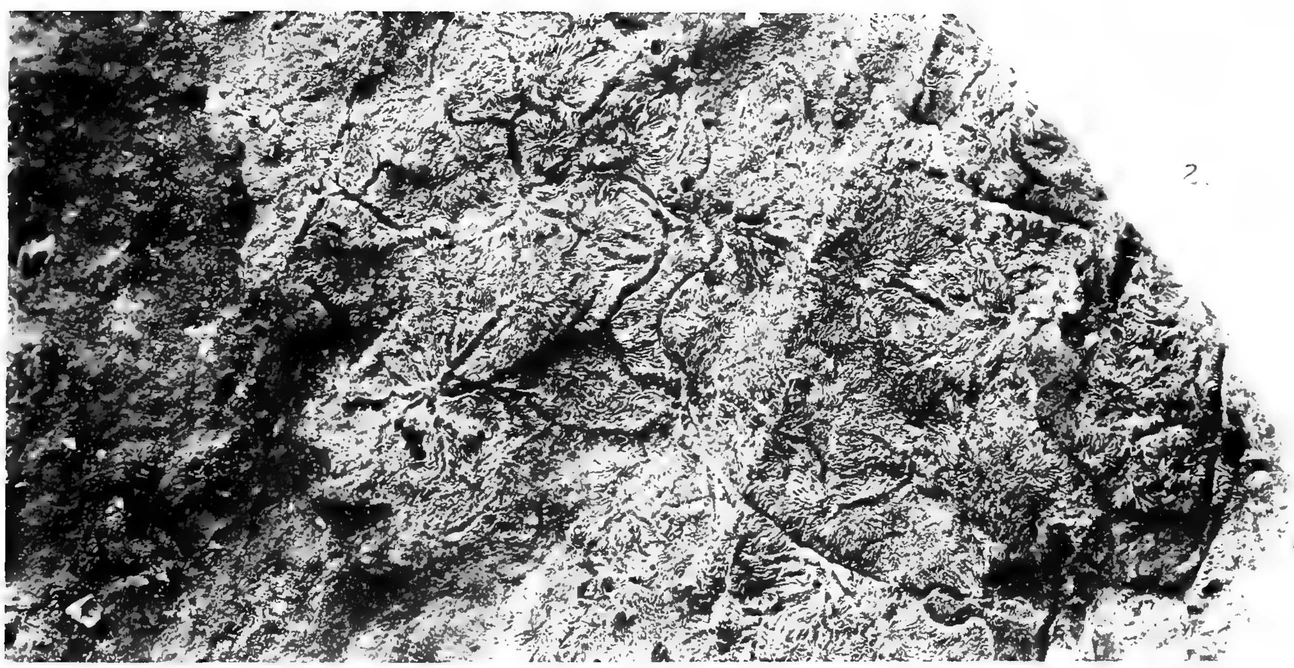
3*a*. Part of the same specimen, seen from below.

Fig. 4. *Tetilla dactyloidea* (Carter) var. *lingua*, nov.

Two of the type specimens, nat. size.

The figures on this plate are reproductions of direct photographs.





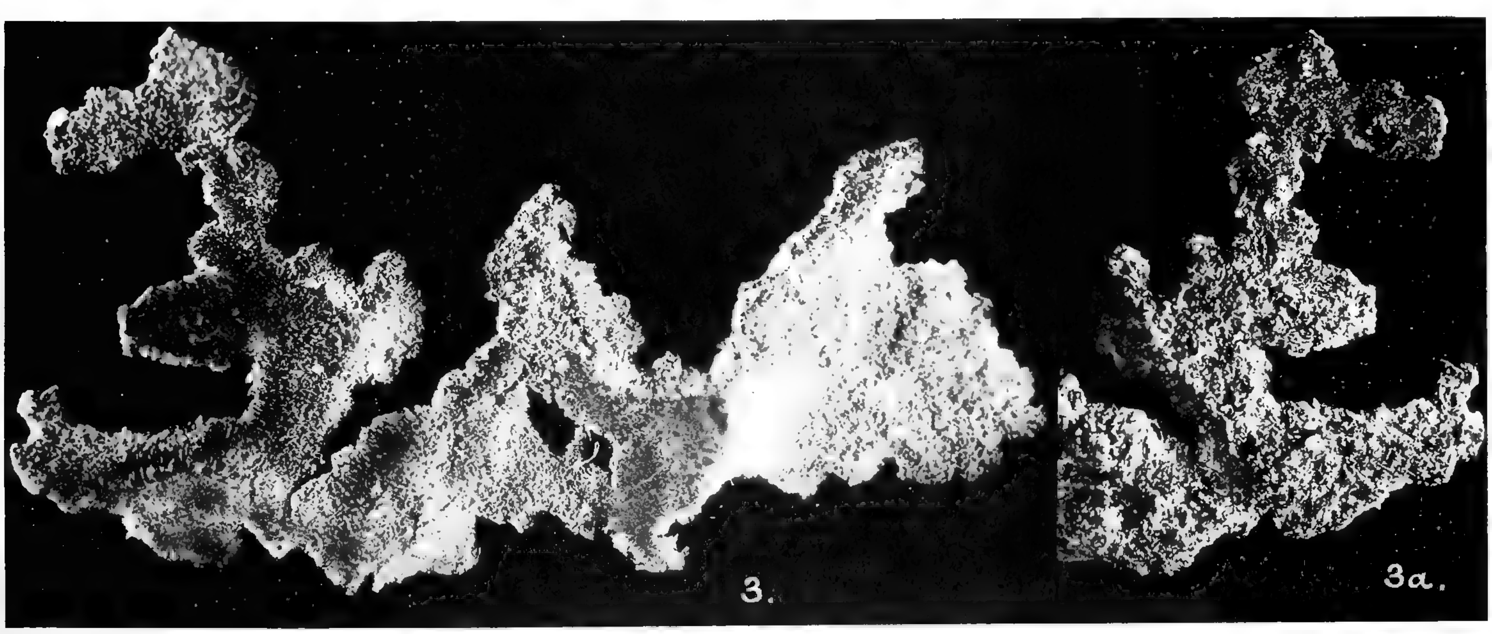


Photo. by S. C. Mondul & A. Chowdhary. Bemrose, Collo., Derby.

SPONGES OF THE CHILKA LAKE.

FAUNA OF THE CHILKA LAKE

THE ECHIUROIDEA OF THE LAKE AND OF THE GANGETIC DELTA.

By N. Annandale, *D.Sc., and* Stanley Kemp, *B.A.*

(With 2 text-figures.)

CONTENTS.

ECHIUROIDEA.

By N. ANNANDALE *and* STANLEY KEMP.

The Gephyrea are represented in the fauna of the Chilka Lake by a single Echiuroid belonging to the genus *Thalassema,* Gaertner. The species, which appears to be undescribed, is of interest on account of its close relationship to *T. sabinum,* Lanchester, from the Talé Sap in lower Siam (a lagoon that closely resembles the Chilka Lake in many respects) and of the fact that a third closely related species occurs in canals of brackish water on the outskirts of Calcutta.

These three forms belong, in a sense, to the group typified by *T. neptuni,* Gaertner (the type species of the genus) and characterized by the comparatively simple nature of the anal trees, by the possession of two pairs of nephridia and by the undivided sheath of longitudinal muscles. They have, however, certain very noteworthy peculiarities—especially in the structure of the proboscis—that may ultimately be considered to be of generic importance. The following key to the species of the *neptuni* group, to which we assign provisionally those described here, may be useful :—

I. Proboscis long and slender, pointed or bifid at the tip, extremely extensile, without dendritic or finger-shaped outgrowths.
- A. Proboscis when expanded much longer than body, pointed .. .. *T. neptuni,* Gaertner.
- B. Proboscis when expanded not much longer than body, expanded and bifid at tip .. .. *T. semoni,* Fischer.

II. Proboscis short and stout, truncate at tip, not very extensile, with dendritic or finger-shaped outgrowths.
- A. Proboscis tubular, (the lateral margins being fused together), and containing internal finger-shaped outgrowths .. .. *T. sabinum,* Lanchester.
- B. Proboscis with the lateral margins not fused together, though capable of close apposition, bearing dendritic marginal outgrowths.
  - 1. Dendritic outgrowths of proboscis small, less than half as long as it is wide .. *T. dendrorhynchus,* sp. nov.

2. Dendritic outgrowths gill-like, nearly as long as the proboscis is wide .. .. *T. branchiorhynchus*, sp. nov.

We have to thank Dr. A. E. Shipley and Mr. Forster Cooper for sending us the two type specimens of *T. sabinum* for comparison with those of our new species.

Genus **THALASSEMA**, Gaertner.

1913. *Thalassema*, Wharton, *Philippine Journ. Sci.*, VIII, p. 243.

Thalassema dendrorhynchus, sp. nov.

Like all Echiuroids this species is contractile; but the body is much more so than the proboscis (though the latter is capable of undergoing considerable change of form) and neither region appears to be so extensile as in many other species.

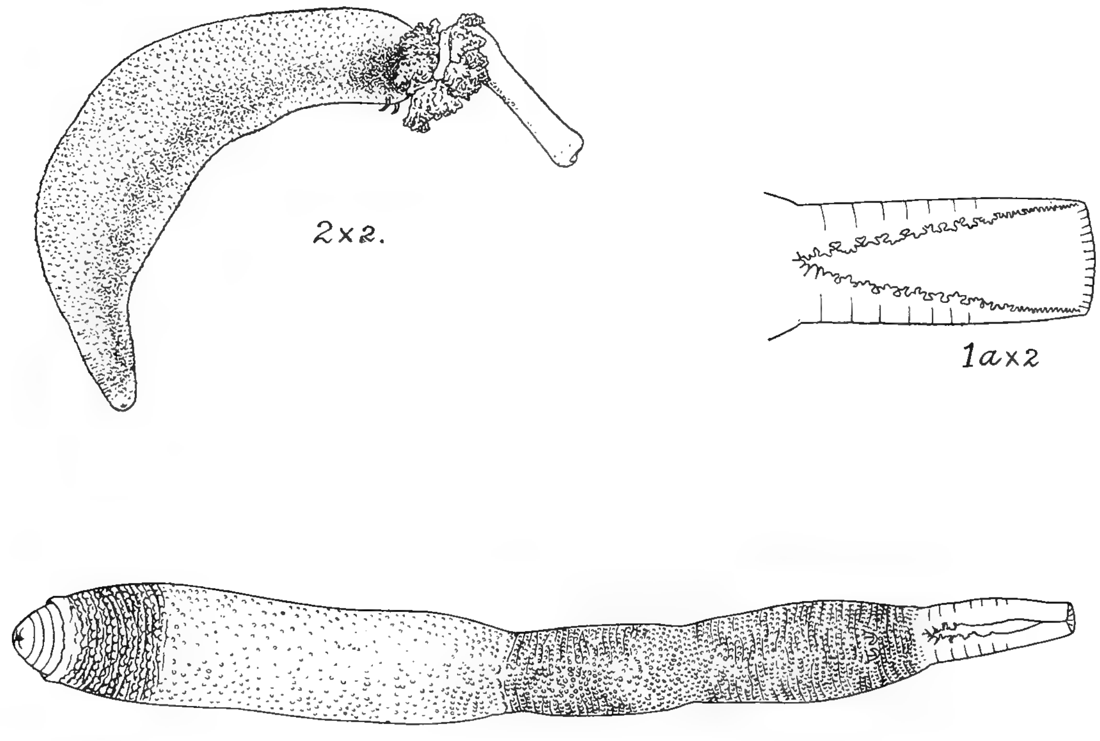


FIG. 1.—*Thalassema dendrorhynchus*, sp. nov. (nat. size); 1*a*, ventral view of proboscis with lateral margins separated (× 2).
FIG. 2.—*Thalassema branchiorhynchus*, sp. nov. (× 2).

Our largest specimen (fig. 1), preserved fully expanded, is 120 mm. in total length, of which 18 mm. is occupied by the proboscis. The greatest breadth is 12 mm., the point at which this measurement was taken being near the posterior extremity. The animal is, however, able to contract its body at different points and the position of the greatest breadth differs from time to time. In our smallest specimen, preserved in a contracted condition, the length is 46 mm., of which about 8 mm. is occupied by the proboscis; the greatest breadth, situated near the centre of the body, being again about 12 mm. In general form this specimen may be described as sausage-shaped.

The proboscis, the length of which is thus about one-sixth or one-seventh that of the entire animal, is shovel-shaped; the distal extremity is truncate and the lateral (ventral) margins are capable of being applied together in such a way as to form a cylindrical tube. When separated the space between them is narrowly V-shaped. The dorsal surface is smooth or nearly so. There is no longitudinal ridge on the ventral surface and the ciliated groove is inconspicuous. A striking feature of the margins is that they are distinctly serrated, the serrations towards the proximal end gradually taking the form of dendritic outgrowths, which, however, are always shorter than half the width of the whole organ (fig. 1*a*).

In certain conditions of expansion the basal part of the proboscis has the appearance of being annulated and the distal extremity is marked by short parallel longitudinal grooves.

The body is covered with papillae which are most numerous towards the two extremities, where they tend to be arranged in concentric rings emphasized by corresponding circular folds in the integument. This is more marked in the posterior region, where the papillae are also larger, than in the anterior. There is a considerable area in the posterior half of the body where they are scattered and comparatively small. The ventral hooks are of a bright golden colour, but in two of our specimens the tips appear to have been broken off. Even when complete they are small and only conspicuous on account of their colour. They are situated close together and their distance from the base of the proboscis is considerably shorter than its length. The exact point at which they occur is not, however, constant.

The circum-anal region is devoid of papillae, but surrounded in a more or less definite manner by several concentric folds, the most conspicuous of which separates it from the densely papillate region immediately in front. As a whole it is conical, but the part actually bordering the anus can be thrust out to form a short tubular process.

The longitudinal muscles form a continuous sheath.

There are two pairs of nephridia, both of which open behind the level of the ventral hooks. The internal funnel of each is provided with a pair of very long, fine, spirally-twisted filaments which arise at either side of its orifice. The vesicle is narrow and finger-shaped, tapering to a blunt apex which points inwards.

The anal trees are short and simple, nearly half the length of the body in a contracted specimen. They have a slight brownish tinge and the walls are very thin; the distal part is narrowly cylindrical, but the apex is blunt; the basal or proximal part is somewhat swollen, but there is no definite vesicle. No funnels are visible with the aid of a hand-lens and there are no muscular strands attaching the organs to the body-wall. Examined under the microscope, each tree is seen to possess two longitudinal rows of minute ciliated funnels, the mouth of which does not exceed 0·047 mm. in breadth, while the length is not greater than 0·168 mm. The two trees open separately into the intestine close to the anus.

The alimentary canal is extremely long and intricately but irregularly coiled. Its calibre is small at all points and the walls are thin and transparent. For a

considerable part of its length it is closely packed with small oval pellets of mud. The canal is joined to the body-wall by numerous slender muscular strands which are very easily detached.

The natural colouration is much less conspicuous than in some species of the genus. The body-wall is translucent in life with a pale vinous tinge; but the mud in the alimentary canal makes it seem much darker, sometimes nearly black. The circum-anal region is dead white, the proboscis cream-coloured, with the free edges and the dendritic outgrowths tinged with brown. There are several opaque longitudinal streaks on the body which simulate muscle-bands. Specimens become opaque in spirit and lose their colour completely.

Apart from the Gangetic species (which we describe as *T. branchiorhynchus*) *T. dendrorhynchus* is most nearly related to *T. sabinum*, Lanchester.[1] The only published description of the latter is very incomplete; but, as has already been stated, we have been able to examine the type-specimens. The most important diagnostic character is the fact that the lateral margins of the proboscis are fused, so that the organ is tubular. Comparatively long finger-shaped processes arise from its internal surface and protrude at the opening of the tube. Otherwise, except for its small size and comparatively smooth external surface, the species closely resembles *T. dendrorhynchus*.

Fischer's description of *T. semoni*,[2] which was based on specimens that had lost their proboscis, shows that the internal anatomy is similar in most respects to that of the Chilka species; but Shipley's figure of a living individual[3] proves that a wide difference exists in the structure of the missing organ. Wharton, in the paper cited above, has recently redescribed *T. semoni*, which is an Indo-Pacific form.

So far as published figures of the entire animal are concerned, *T. dendrorhynchus* most closely resembles *T. kokotoniense*, Fischer,[4] another form widely distributed in the Indo-Pacific region, but in the latter species the longitudinal muscles are divided into bands and the body-wall is apparently much stouter.

Specimens from the Chilka Lake were very sluggish when removed from the mud in which they were taken. The only movements exhibited were quite unrhythmic contractions, both transverse and longitudinal, of the body-wall and proboscis; the latter showed no signs of great extensibility or of readiness to break off, and its movements did not suggest that it was employed in burrowing.

A female killed in February contained immature ova.

We found only three specimens of *T. dendrorhynchus*, all in the southern part of the main area of the Chilka Lake. They were living, probably rather deeply buried,

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[1] *Proc. Zool. Soc. London*, 1905 (I), p. 40, pl. ii, fig. 5.

[2] In Semon's *Zool. Forsch. Australien*, V, p. 338, fig. 4 (1896).

[3] In Gardiner's *Faun. Geogr. Maldives and Laccadives* I, p. 129, pl. vi, fig. 4 (1903).

[4] See Shipley in Willey's *Zool. Res. New Britain and New Guinea*, p. 337, pl. xxxiii, fig. 3 (1898-1902).

in dense mud. The largest of the three was brought up on the anchor of the launch between Barkuda Id. and the mainland in April; the other two were taken out in the lake between Barkuda and Chiriya Ids. in February; the specific gravity of the water varying from 1·006 on the former occasion to 1·009 on the latter. The species is doubtless a permanent inhabitant of the southern part of the lake and must at times be brought in contact with water that is almost fresh. The habits of the species render it unlikely to be captured except occasionally, and we have no means of ascertaining whether it is actually scarce.

Our specimens of *T. dendrorhynchus*, the types of the species, are numbered Z.E.V. 6800-6803/7 in the register of the Indian Museum collection.

Thalassema branchiorhynchus, sp. nov.

This species (fig. 2, p. 58) is closely related to *T. dendrorhynchus*, but differs in the following characters:—

(1) The proboscis is relatively longer and more slender, its length when fully expanded being more than one-third that of the body.

(2) The dendritic outgrowths of its margin are much more highly developed, having a gill-like appearance (fig. 3) and being of a blood-red colour in life; they are confined to the proximal third of the margin, the distal part of which is quite smooth.

(3) There is a conspicuous longitudinal ridge (in place of the ordinary ciliated groove) on the proximal part of the ventral surface of the proboscis between the two rows of dendritic outgrowths. These it resembles in colour.

(4) The external (dorsal) surface of the proboscis is minutely tubercular instead of being smooth.

(5) The integument of the body remains translucent even in spirit, the nerve-cord being visible externally as an opaque white line.

(6) The surface papillae of the body are less prominent than in *T. dendrorhynchus*; they are, as a rule, distinctly of two kinds, large and small, the large papillae being most numerous towards the two extremities. Near the posterior end they are conical and show some tendency to be arranged in transverse rings. There is, however, no smooth circum-anal region.

The length of the body in the type-specimen (fully expanded) is about 32 mm. and the greatest breadth about 7 mm.; the length of the proboscis nearly 15 mm.

In the living animal the whole body was of a deep reddish vinous tint, translucent, but not markedly so. The posterior extremity was somewhat paler than the remainder and the colour seemed to be due mainly to the fluid of the body-cavity. The proboscis was purplish pink, contrasting notably with the bright red colour of its dendritic outgrowths and the ridge on the ventral surface. The hooks were golden yellow tipped with black.

The internal structure of this species agrees closely with that of *T. dendrorhyn-*

chus, the only differences detected being that the processes of the nephridial funnels were less distinctly coiled and the anal trees possibly longer. In the fully expanded specimen the latter are about half as long as the body, but it was noticed in the living animal that their relative length varied with the state of general expansion and that they were not so extensile as the body as a whole. The arrangement and form of the minute funnels on the trees seem to be identical in the two species.

Our specimen from the Gangetic delta was active. When placed in a dish of mud and water, the animal formed for itself, by irregular movements of the body and proboscis, a shallow groove on the surface of the mud. It made no attempt to burrow downwards, but lay on one side in this groove. When first removed from the water it writhed vigorously and changed its shape rapidly in diverse regions, sometimes extending itself to a considerable length and assuming a worm-like form, sometimes

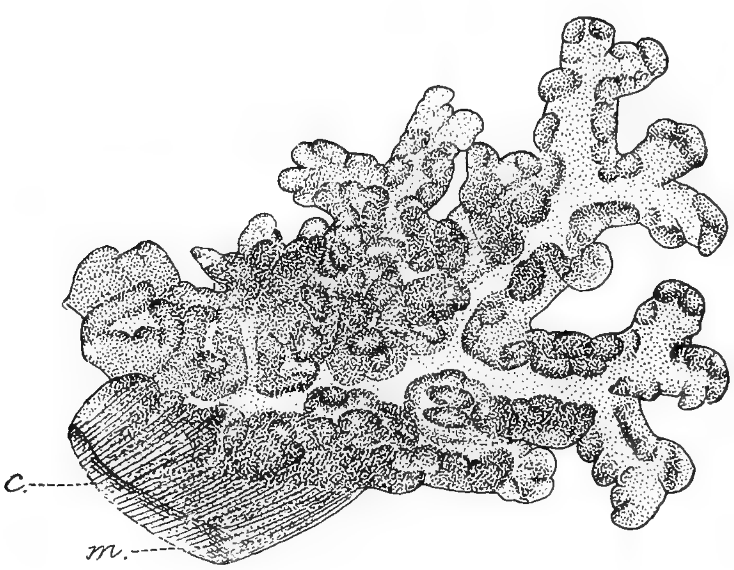

FIG. 3.—*Thalassema branchiorhynchus*, sp. nov.

Gill-like outgrowth from base of proboscis, seen from ventral surface, × 30.

c = lumen of base of outgrowth, which is cut off a little obliquely ; *m* = muscles entering base.

expanding the extremities or other parts of the body into bulbous or annular swellings. When it was replaced in its natural element these movements continued for a short time, but soon became less vigorous, though without ceasing completely. The natural attitude of the proboscis appeared to be flexed backwards, so that its dorsal surface was in contact with that of the body. The distal parts of the lateral borders were applied together so as to form a complete tube ; but the proximal parts were everted (fig. 2, p. 58), the dendritic outgrowths being thus displayed. They were somewhat contractile and, when fully extended and spread out, formed a double series of short feathery tentacles. The whole proboscis was, however, sometimes twisted spirally, as is shown in the figure.

The only known specimen of *T. branchiorhynchus* was taken in about 3 feet of water in a small tidal creek connected with a canal near Chingrighatta on the outskirts of Calcutta in December, 1914. The specific gravity of the water was then 1·006.

We have failed to obtain further specimens, but this does not necessarily mean that the species is scarce, for, from the point of view of the collector, the Gangetic mud is very difficult to deal with in a satisfactory manner.

The specimen bears the number Z.E.V. 6807/7 in the Indian Museum books.

T. dendrorhynchus, the Gangetic species, and *T. sabinum*—despite the specific name of the last—all live in peculiarly dense mud, and we believe that the unusual structure of the proboscis in the three species is correlated with this fact. It is noteworthy that the gill-like outgrowths are better developed in the species from the Gangetic delta than in that from the Chilka Lake, for the mud of the former region is extremely fine and therefore forms a peculiarly dense and sticky mass.

In most species of *Thalassema* the proboscis seems to be the most active agent in burrowing or in insinuating the body into crevices, but apparently this is not the case in the three mud-living species just discussed. In these species the excavations are formed by movements of both the body and the proboscis, and the latter has probably a respiratory as well as a muscular and a nutritive function, for the dendritic outgrowths of its margins or ventral surface have much the appearance and structure of gills and are situated in such a position that all water which enters the mouth must first pass over them. Externally, in *T. dendrorhynchus* and *T. branchiorhynchus*, they are covered with ciliated epithelium; they contain spacious lumina that communicate with the body-cavity by means of a longitudinal canal at their base. The other parts of the proboscis are highly muscular, the bulk of the organ consisting of a gelatinous substance that contains numerous bundles of longitudinal muscle-fibres. In *T. dendrorhynchus* these are most numerous towards the ventral surface, from which they proceed outwards, in transverse section, in somewhat irregular bands that become gradually attenuated. Single transverse fibres run in the opposite direction among the bundles and shorter fasciae also occur in the ventro-dorsal axis between the bands. Immediately below the ectoderm on both ventral and dorsal surface, there is a relatively broad horizontal muscle running across the proboscis.

FAUNA OF THE CHILKA LAKE

THE COELENTERATES OF THE LAKE, WITH AN ACCOUNT OF THE ACTINIARIA OF BRACKISH WATER IN THE GANGETIC DELTA.

By N. ANNANDALE, *D.Sc., F.A.S.B.*

(Plates VI–IX.)

CONTENTS.

COELENTERATES.

By N. ANNANDALE.

As will be seen from the list on p. 69, we obtained specimens of sixteen species of coelenterates in the Chilka Lake, *viz.* six Actinozoa, one Scyphomedusa and nine Hydrozoa. Five of the Actinozoa are Actiniaria and one an Alcyonarian; the Scyphomedusa belongs to the order Rhizostomata; one of the Hydrozoa is a Narcomedusa and one a Siphonophoran, while the remainder are true hydroids or hydromedusae, including four Calyptoblastea and three Gymnoblastea. Of the Calyptoblastea it is possible that a hydroid and a medusa actually represent the different generations of a single true species.

Of the Alcyonarian (a species of *Virgularia* probably not yet named) I propose to say no more at present than that it also occurs in the Gangetic estuaries. Our specimens are in the hands of a specialist, who will doubtless describe them in due course.

The Actiniaria are perhaps the most interesting group represented, for not only do they include species of the primitive genera *Edwardsia* and *Halianthus*, neither of which appears to have been found hitherto in the Indian Ocean, but they also include two species of Metridiine Sargatiidae that are here described as the types of new genera. These genera are apparently specialized for different phases of life in conditions such as occur in the Chilka Lake and in the Gangetic delta. Notwithstanding their high degree of apparent secondary specialization, it is possible that the type-species of one of them is in reality no more than a permanent post-larval form of *Metridium schillerianum*, long known from the estuarine tracts of the Ganges. All the species of Actiniaria found in the Chilka Lake occur in its main area, in which it is evident that they are permanent residents. Most of them, if not all, are, however, to some extent affected by the seasonal irruption of fresh water and probably only a few individuals of each survive annually to perpetuate their kind.

The only Scyphomedusa we obtained is also a permanent inhabitant of the main area of the lake, in which we have evidence that it breeds regularly, though it occurs also in the Bay of Bengal. A fortunate accident made it possible to study the direct effect of fresh water on the general physiology and the structure of this species, not only in the Chilka Lake but more particularly in the Ennur backwater near Madras.

The Coelenterata of the lake fall into three classes biologically: (1) casual visitors from the sea; (2) periodic immigrants from the Bay of Bengal; and (3) permanent inhabitants of brackish water or of water subject to great changes in salinity. The first group consists of a few surface or midwater forms of which individuals are

occasionally carried into the outer channel, and of at least one hydroid washed into the main area on drifting weed. To the second category belong several hydroids that are able to establish themselves in the salt-water season in the outer channel but perish in the summer floods; while to the third must be assigned all the Actiniaria, the one Alcyonarian, the one Scyphomedusa and at least two hydroids. The number of species that may be tabulated under each of the three headings is as follows:—

Casual visitors	4
Periodic immigrants	3
Permanent inhabitants	9
TOTAL ..	16

The casual visitors include one Narcomedusa, one Siphonophoran and two Calyptoblastic Hydrozoa, one of which is represented by the medusoid generation only; the periodic immigrants consists of one Gymnoblastic and one Calyptoblastic hydroid, with a medusa that may be no more than the fertile generation of the latter; while as permanent residents may be classed five Actiniaria, one Alcyonarian, one Scyphomedusa and two Gymnoblastic hydroids.

ACTINIARIA.

(Plate vi (in part), plates vii, vii*a*).

The Actiniaria of the Chilka Lake belong to three families, five genera and five species. The three families are the Actiniidae, the Sagartiidae and the Edwardsiidae. The first is represented by a single new species of the genus *Gyrostoma*, the second by two species each of which is placed in a new genus, and the last by new species of *Halianthus* and *Edwardsia*. With one exception (that of a Sagartiid previously found in the Gangetic delta) all the species are here described or named for the first time—a fact that is not surprising in view of our present ignorance of the actinian fauna of the Bay of Bengal[1] and of the estuaries and lagoons connected therewith.

From a geographical point of view the most interesting feature of the Chilka species is the occurrence among them of *Edwardsia* and *Halianthus*, genera known from both northern and southern regions but apparently represented but poorly in the Tropics.

Biologically the most important forms are those here accepted as the types of new genera of Sagartiidae. Their significance is discussed at some length on pp. 72-76, *postea*. The apparent effect of the irruption of fresh water into the lake on the species of *Halianthus* is another interesting feature of the fauna (see p. 91), and may

[1] The only papers on the sea-anemones of the Bay of Bengal that I can trace are those by Alcock in the *Journal of the Asiatic Society of Bengal* (vol. LXII, part 2, pp. 151 and 169: 1893), and by Haddon in the *Journal of the Linnean Society* (Zool., vol. XXI, p. 247: 1888). These papers deal with a few species only.

COELENTERATES OF THE CHILKA LAKE.

m.a. = main area: o.ch. = outer channel: sp. gr. = specific gravity of water in the lake.
Species whose names are marked with a star have been found only in the Chilka Lake.

	Chilka Lake.		Further Distribution.	Sp gr.
	m.a.	*o.ch.*		
ANTHOZOA.				
Actiniaria.				
Actiniidae.				
*Gyrostoma glaucum** ..	x	x		1·0075—1·02575
Sagartiidae.				
*Phytocoetes chilkaeus** ..	x	x		1·0105—1 0265
Pelocoetes exul ..	x		Gangetic delta (*brackish water*).	1·005—1·010
Edwardsiidae.				
*Halianthus limnicola** ..	x	x		1·000—1·0257
*Edwardsia tinctrix** ..	x	x		1·000—1·0257
Alcyonaria.				
Virgulariidae.				
Virgularia sp. ..	x		Gangetic delta (? *salinity*).	
SCYPHOMEDUSAE.				
Rhizostomata.				
Rhizostomata Triptera.				
Acromitus rabanchatu ..	x	x	Bay of Bengal (*marine*).	1·000—1·02575
HYDROZOA.				
Narcomedusae.				
Aeginidae.				
Solmundella bitentaculata ..		x	Practically cosmopolitan (*marine*).	1·02575
Siphonophora.				
Diphyidae.				
Diphyes bojani ..		x	Indian and Pacific Oceans (*marine*).	1·02575
Calyptoblastea.				
Campanulinidae.				
Campanulina ceylonensis ..		x	Bay of Bengal; G. of Manaar; Gangetic delta (*salt and brackish water*).	1·02575
Campanulariidae.				
Obelia spinulosa ...	x		N. S. Wales; Java: Andamans (*marine*).	1·02575
Clytia serrulata ..		x	N. S. Wales (*marine*).	*ca.* 1·006
*Phialidium cruciferum** ..		x	Perhaps the medusa of *C. serrulata*.	1·02575
Gymnoblastea.				
Bougainvilliidae.				
Bimeria fluminalis .	x	x	Gangetic delta (*brackish water*).	1·000—1·02575
Corynidae.				
Dicyclocoryne filamentata ..	x		Gangetic delta (*brackish water*).	*ca.* 1·0150
Hydractiniidae.				
Clavactinia gallensis ..		x	G. of Manaar (*marine*).	1·02575

be compared with that noted in greater detail in the case of the medusa *Acromitus rabanchatu* (see p. 101); generally speaking, this change in environment seems in both cases to induce a period of physiological quiescence accompanied by a shrinkage of the mesogloea and is probably fatal to a large number of individuals, though not to the species as a whole.

With my account of the Chilka species I have included a description of a new Gangetic anemone co-generic with one of the former, and also some notes on another Gangetic species that has long been known but is of particular interest in reference to the question of the origin of the fauna of brackish water. These Gangetic species are *Phytocoetes gangeticus*, sp. nov. and *Metridium schillerianum* (Stoliczka).

Family ACTINIIDAE.

Genus **Gyrostoma**, Kwietniewski.

1900. *Gyrostoma*, Carlgren, *Mitt. Naturh. Mus. Hamburg*, XVII, p. 55.
1905. ,, McMurrich, *Zool. Jahrb.*, Suppl. VI (III), p. 226.

The only representatives of the Actiniidae found in the Chilka Lake belongs to the genus *Gyrostoma* as redefined by the authors cited. The genus is represented in all the warmer seas and species have been described from East Africa, South Australia, Torres Straits and the West Indies.

Gyrostoma glaucum, sp. nov.

(Plate vii*a*, fig. 1.)

In life the animal is of an almost uniform glaucous green colour, but in some individuals there are darker V-shaped cross-bars on the upper surface of the tentacles. The column is slender and more or less vase-shaped, much longer than broad when fully extended. The external surface is smooth to the naked eye, except when the circular muscle is strongly contracted, but is covered with scattered microscopic prominences provided with nematocysts. The contracted muscles are visible as distinct annuli which, in preserved specimens, are more opaque than the expanded parts of the column.

The oral disk is rather narrow, circular in outline, flat but ridged and grooved radially. The mouth, which is provided with not very prominent lips, is almost linear and occupies about two-thirds of the circle in its longer axis. The tentacles are moderately long and slender; when fully expanded they are pointed, but even a slight contraction produces a faint ovoid swelling of the tips due to a greater thickness of the wall (mainly the ectoderm) in this region. The outer circle consists of about 24 tentacles distinctly longer and stouter than any of the others Within this circle there are four others, but neither the number nor the arrangement is at all regular. Some of the tentacles of the innermost circle, though smaller than the outermost ones, are larger than the majority. These are often thrust into the mouth.

The basal disk, though small and not extending beyond the margin of the column,

is thick and muscular. It is capable to some extent of retraction, the margin of the retracted portion being angular in vertical section. There is a minute central aboral pore.

There are twelve complete and thirty-six incomplete mesenteries, the latter being situated in the intermesenterial spaces only, six in each. The two central incomplete mesenteries in each space are fertile. The longitudinal muscles are very feebly developed and in strictly horizontal sections the width of the mesenteries is almost uniform throughout, the folds at the base on both sides in particular being diffuse and poorly developed. The two pairs of directive mesenteries are very short.

The stomodaeum is ample and extends much more than half way down the column in a state of expansion.

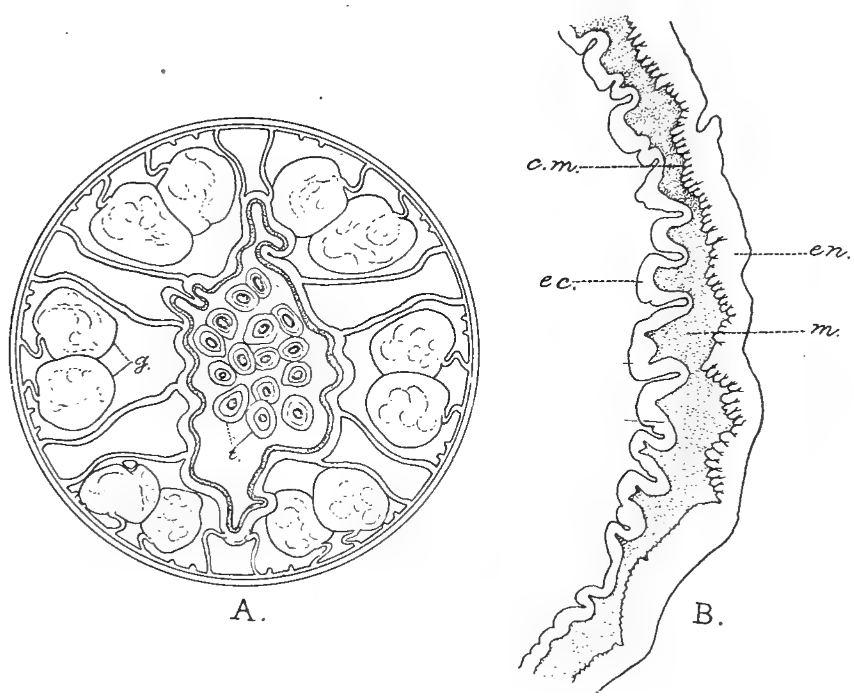

FIG. 1.—*Gyrostoma glaucum*, sp. nov.

A. Transverse section through the column in the lower part of the stomodaeum.

B. Vertical section of the lower part of the sphincter.

c.m. = circular muscle: *ec.* = ectoderm: *en.* = endoderm: *g.* = gonad: *m.* = mesogloea: *t.* = tentacles thrust into mouth.

The column-wall is thin, the mesogloea in particular being scanty. The circular muscles lie at the base of the endoderm and are not very highly developed. The sphincter is little if at all differentiated from any other part of the sheath in a state of contraction. When the tentacles are fully everted there is, indeed, a region just below the disk in which its folds are a little stronger than in the region immediately succeeding it; but similar folds may also be observed in the aboral half of the column. These features are indicated by increased opacity and stronger annulation of the body-wall (pl. vii*a*, fig. 1).

The length of the column of our largest specimen was, fully expanded, 10 mm.; that of the other adults about half as much.

Type. No. Z.E.V. 6825/7, *Ind. Mus.*

In this brief description I have not attempted more than to give a concise statement of the characters that seem to be of specific importance. Only five adult specimens are available for examination and, so far as I can judge from the species of other families that I have examined in much larger numbers, the so-called anatomical characters of the Actiniaria are liable not only to great individual variation but also to much momentary change in correlation with expansion and contraction of the muscles and mesogloea, apart altogether from the fact that distortion is almost inevitably produced in the course of preservation.

In external appearance *Gyrostoma glaucum* bears some resemblance to von Ehrenberg's figure of *Entacmaea olivacea*[1] (=*Paractis olivacea*, Klunzinger), but differs therefrom in the greater relative length of its outer tentacles.

G. glaucum has been taken as yet only in the Chilka Lake, in which it appears to be very scarce. It occurs both in the main area and in the outer channel. A single specimen was taken near the mouth of Rambha Bay in February, at a depth of between 5 and 7 feet and in water of a sp. gr. of 1·0075, while four others of much smaller size were obtained in the channel between Satpara and Mahosa in March, from about the same depth and in water of sp. gr. 1·02575. Three others[2] of still smaller size and evidently immature were found in the oyster-beds at Manikpatna in the same month.

Family SAGARTIIDAE.

Subfamily *METRIDIINAE*.

In discussing the species of this subfamily found in the Gangetic delta inexperience led me in 1907 into a taxonomic error, but this error, having some biological justification, has proved not unprofitable in considering the actinians of the Chilka Lake. In 1907[3] I ascribed three forms from Port Canning to the genus *Metridium* and to the species described by Stoliczka[4] in 1868 and 1869 as *Sagartia schilleriana*. One of these, there is no doubt, was identical with that species, of which my specimens were topotypes in the strictest sense of the term and of which the actual types are still available for comparison in Calcutta; another I described as a variety (*exul*), while the third I regarded as the young of the second. These three forms are here placed in three distinct genera, of which two are described as new, while Stoliczka's species is left in *Metridium*.

As the two new genera are both represented in the Chilka Lake, it will be convenient to discuss here the relationships of one to the other and of both to *Metridium*. Differences may first be noted. The species of *Metridium* are all anemones with a well-developed basal disk by means of which they cling firmly to solid objects.

[1] See Zoologica 11, Phytozoa, pl. viii, fig. vi, in *Symbolicae Physicae*, edited by O. Carlgren (1899) and Klunzinger's *Korallthiere des Rothen Meeres* 1, p. 70, pl. v, fig. 7, pl. viii, fig. 8 (1877).

[2] These had only 24 tentacles arranged in two circles, an outer circle of 8 and an inner one of 16; the latter was, however, incompletely differentiated into two subsidiary circles.

[3] *Rec. Ind. Mus.* I, p. 35.

[4] *Proc. Asiat. Soc. Bengal*, 1868, pp. 174, 263, and *Journ. Asiat. Soc. Bengal*, XXXVIII (2), p. 31 (1869).

Their body-wall is thin and not particularly muscular; they have twelve complete mesenteries, an ample oral disk and a large number of slender tentacles arranged in several or many cycles. For the two new genera I propose the names *Pelocoetes* and *Phytocoetes*. The former, as its name indicates, is a dweller in mud, while the latter lives, free or lightly attached, among weeds, in sponges or in holes in logs of wood. The generic peculiarities of *Pelocoetes* are so marked that at first sight it might be placed in a different family from *Metridium*. It is a typical burrower with an elongated vermiform body, and a muscular though by no means thick body-wall. Its oral disk is highly specialized, the arrangement of its tentacles peculiar. *Phytocoetes* has an elongated, but not a vermiform column. Its oral disk remains normal, but the number of its tentacles, which exhibit no marked peculiarity in arrangement, is somewhat reduced. In both genera little practical use is made of the aboral disk, but it has not entirely disappeared and is to some extent functional. In both genera, notwithstanding this fact, the lower extremity of the column bears, both functionally and structurally, a remarkable resemblance to the physa of such types as *Edwardsia* and *Cerianthus* that totally lack an aboral disk.

If this were all that could be said about the three genera it would appear that they were very distinct, and that *Pelocoetes* and *Phytocoetes* differed considerably, one from another and both from *Metridium*. But an examination of the anatomy and even of the external characters reveals very striking resemblances, and, although there would be no difficulty in distributing a set of living anemones into their respective genera, there is often a very real difficulty in sorting out specimens preserved in alcohol. The colouration of the known species is identical or almost so; all have the same translucent watery appearance, the same absence of intrinsic pigment;[1] the arrangement of the mesenteries is the same, except that the cycles of incomplete septa differ in number, while the musculature of the body-wall is very similar; the structure of the gonads, of the muscle-banners and of the individual tentacles appears to be practically identical.

The fact that these three genera live together in circumstances very unfavourable to their group as a whole (*viz.* in estuaries, creeks, pools and lakes in which the water is much fresher than normal sea-water and subject, moreover, to great and even sudden changes in salinity; in which the bottom is composed of soft mud; in which rocks covered at all seasons and even stiff water-weeds are practically absent) must not be forgotten in considering their relationships.

Metridium schillerianum, the species originally described from the Gangetic delta, maintains itself by clinging tightly to floating logs, which are by no means common in the Gangetic delta, and to posts fixed on the edge of canals and creeks. It is a normal member of its genus, which is probably cosmopolitan in distribution and essentially marine. Of the three genera, *Metridium* is certainly the most primitive and, indeed, may be the ancestral form of the other two, both of which are

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[1] The colouration of all these brackish-water species appears to be due to the presence of Zoochlorellae and of a minute purple alga in the endoderm.

evidently adapted in structure for life in different phases of the same environment. The peculiarities of *M. schillerianum* are mainly physiological; to these are added, in the case of *Pelocoetes* and *Phytocoetes*, special structural characters.

In 1907 (*op. cit.*) I expressed the opinion, somewhat tentatively, that the type now called *Pelocoetes* was a variety, local race, or possibly an unfixed phase of *Metridium schillerianum* produced by isolation, and that the form here recognized as a distinct genus under the name *Phytocoetes* was merely the young of *Pelocoetes*. This view ignored, perhaps rightly, the fact that many individuals of the *Phytocoetes* type are sexually mature. In any case it is rendered untenable in its entirety by the discovery in the Chilka Lake of anemones of both the *Pelocoetes* and the *Phytocoetes* types. Stress must be laid, nevertheless, on the resemblance between the latter type and the young of the Sagartiidae. In *Sagartia troglodytes*[1] the young, at any rate in some cases, is born as a small actinian differing from its parents mainly in the smaller number of its tentacles and mesenteries, in the poorly developed condition of its basal disk, in the tendency displayed by its column to assume at one time a spherical or subspherical, at another an elongated shape, and in its much more mobile habits. These are precisely the differences between *Phytocoetes* and *Metridium*. Some years ago I obtained the young of *M. schillerianum* from individuals taken from a post in the Mutlah estuary, and kept them in an aquarium full of water from one of the brackish pools at Port Canning. The adults of this species are almost invariably found in hollows on a rough surface (*e.g.* in the empty shells of *Balanus* or among masses of worm-tubes), but the walls and bottom of my aquarium were quite smooth. The young anemones closely resembled those of *S. troglodytes* and were apparently devoid of a columnar collar; they lived for some months and increased considerably in size, without losing their juvenile form. Unfortunately, during my absence from India, the aquarium was allowed to dry up and they perished before a detailed examination could be made. All that can be said about them therefore is that they continued for some months to resemble both *Phytocoetes* and the young of *Sargartia* in outward appearance.

The species of *Phytocoetes* found in the Chilka Lake is distinct from that originally obtained at Port Canning and since taken in the immediate neighbourhood of Calcutta. I have given the latter the name of *P. gangeticus* and the former that of *P. chilkaeus*.

Although on taxonomic grounds I now propose to regard *Phytocoetes* as distinct generically from *Metridium*, the facts of the case, regarded from a biological point of view, seem to point to the probability of the former being no more than a permanent or quasi-permanent larval (or rather post-larval) phase of the latter. In other words, it seems likely that *Phytocoetes gangeticus* bears to *Metridium schillerianum* much the same relationship as the axolotl does to *Amblystoma tigrinum*. *P. chilkaeus* may either be related in the same way to an unknown species of *Metridium* or be a direct descendant of either *M. schillerianum* or *P. gangeticus* in which evolu-

[1] Ashworth and Annandale, *Proc. Roy. Soc., Edinburgh,* XXXV, p. 4 (1904).

tion has produced definite structural changes: the former view seems to me the more probable.

At Port Canning and in the Chilka Lake examples of both *Pelocoetes* and *Phytocoetes* may be found within a radius of a few yards. In both localities the *Pelocoetes* will be deeply buried, at least up to the base of its oral disk, in dense mud. At Port Canning *P. gangeticus* is most abundant in the canals of the sponge *Spongilla alba* and in hollows on its surface, but is also found in abandoned burrows of *Teredo* in the few wooden posts that exist in the pools, and occasionally quite free among filamentous algae; in other parts of the Gangetic delta it occurs, often half-buried in mud, on the roots of reeds. At Rambha *P. chilkaeus* occurs mainly among algae, but there are neither Spongillidae nor worm-bored posts in those parts of the lake in which it has been found.

It is thus evident that while *Phytocoetes* has to some extent the habits of a young Sagartiid, *Pelocoetes* has adopted a mode of life differing from that of any phase of *Metridium*, indeed of any other allied form. All its generic peculiarities—its vermiform body, its reduced disk, even its incapacity to withdraw its tentacles—are correlated with this mode of life, but apart from these features it retains the structure of a Metridiine Sargartiid, and its basal disk is still functional, for if a living individual is examined immediately after being dug out from the mud it will be seen in most instances that the disk, small as it is, adheres to a particle of shell or some other hard body. Although, therefore, the type must be regarded as quite distinct from *Metridium* and *Phytocoetes*, I still believe that it is genetically related to *Metridium schillerianum*, from which it has been evolved directly, most probably in the Gangetic delta. Whether its evolution is due to natural selection (*i.e.* to the survival of individuals that exhibited a slight tendency to burrow, and of their offspring) or to mutation (*i.e.* the sudden appearance of a burrowing strain in the species) there is no evidence to prove; the fact that *Phytocoetes* is intermediate in structure between the two extreme types might seem to support the natural selection theory, but there is as a matter of fact nothing definite to show that the two new genera do not represent different offshoots from the main stem of *Metridium*; and if *Phytocoetes* is a permanent larval form it is difficult to imagine it as an actual step in the ladder of evolution.

My present views on these Metridiinae of Indian estuaries and lagoons, therefore, may be summarized as follows:—

(1) Stoliczka's *Sagartia schilleriana* is a *Metridium*.

(2) The form I described in 1907 as a variety of *M. schillerianum* under the name *exul* is a distinct species and represents a new generic type, for which the name *Pelocoetes* is proposed.

(3) What I took for the young of this form represents a second new generic type, for which I now suggest the name *Phytocoetes*.

(4) *Phytocoetes* is probably a permanent or quasi-permanent post-larval form of *Metridium*.

(5) *Pelocoetes* is probably related genetically to *Metridium schillerianum*, but

has become structurally adapted, without losing certain essentially Metridiine characters, to life as a burrower in mud.

(6) The species of *Phytocoetes* found in the Chilka Lake is distinct from that found at Port Canning, while the *Pelocoetes* is specifically identical in the two localities.

(7) *Metridium schillerianum* does not occur in the Chilka Lake.

The following key to the species of Metridiinae that occur in brackish water in India may be useful to naturalists in this country:—

1. Basal disk large and strongly adherent; column in normal state no longer than wide.
   Tentacles about 168, arranged round the disk in 5 circles .. .. *Metridium schillerianum.*
2. Basal disk reduced, feebly adherent; column elongated.
   A. Tentacles arranged in one circle of 12 and in 12 groups of 5 to 9 each, 72 to 120 in all .. *Pelocoetes exul.*
   B. Tentacles less than 60, arranged in uninterrupted circles.
      i. Tentacles 21–24; anterior sphincter well differentiated, visible on the surface as a prominent ring .. .. .. *Phytocoetes chilkaeus.*
      ii. Tentacles about 36; anterior sphincter practically absent, not visible on the surface .. *Phytocoetes gangeticus.*

Genus **Metridium**, Oken.

1905. *Metridium*, McMurrich, *Zool. Jarhb.*, Suppl. VI, (III), p. 276.

Metridium schillerianum (Stoliczka).

(Plate vii, fig. 1.)

1868. *Sagartia schilleriana*, Stoliczka, *Proc. As. Soc. Bengal*, pp. 174, 263.

1869. *Sagartia schilleriana*, *id.*, *Journ. As. Soc. Bengal* XXXVIII (2), p. 31, pls. x, xi.

1882. *Sagartia schilleriana*, Hertwig, "*Challenger*" *Rep. Zool.* VI, *Actiniaria*, p. 71.

1907. *Metridium schillerianum* (typical form), Annandale, *Rec. Ind. Mus.* I, p. 45, pl. iii, figs. 1, 2, 5.

My description of "the typical form" of this species (1907) should render the identification of specimens a comparatively easy matter, but there are one or two points both in its anatomy and its ecology on which further notes may be useful.

Strictly speaking it is perhaps incorrect to talk of the existence of a sphincter in *M. schillerianum*, for all that can be said is that the circular muscle of the column is thrown into more conspicuous folds a short distance below the disk than elsewhere,

but that the condition of these folds varies considerably in different stages of expansion and contraction of the column. There are as a rule no independent muscle-fibres in this region, but in one specimen (fig. 2) I have found a few widely separated in the mesogloea and without any definite arrangement. When the disk is retracted but the column expanded horizontally, the differentiated region of the muscle-sheath extends over a considerable area; part of it is introverted, while part still remains external.

The facts relating to expansion and contraction of the column and to retraction of the tentacles were not fully understood by me in 1907. When the animal is left dry by the retreat of the tide its tentacles are always retracted, but its column fully expanded. The oral disk is withdrawn for some distance into the column and the walls of the latter are partially closed by a constriction above the tips of the tentacles, but as a rule a small opening remains patent. In this condition the actual body-wall is much swollen and remarkably translucent. If the animal is touched, water is squirted violently from the orifice above the tentacles. I was wrong, however, in thinking (1907, p. 64) that any part of this water was contained between the layers of the wall or in its mesogloea. In specimens killed with the body fully expanded—this is easily accomplished by pouring boiling formalin upon them in a small dish—the column wall will be found to be very thin and to be expanded by liquid within the mesenterial chambers. The mesenterial filaments lie bathed in this water in the middle of the body-cavity. A sudden contraction of the circular muscles of the column causes part of the water to be shot violently out of the mouth and consequently out of the orifice lying immediately above it.

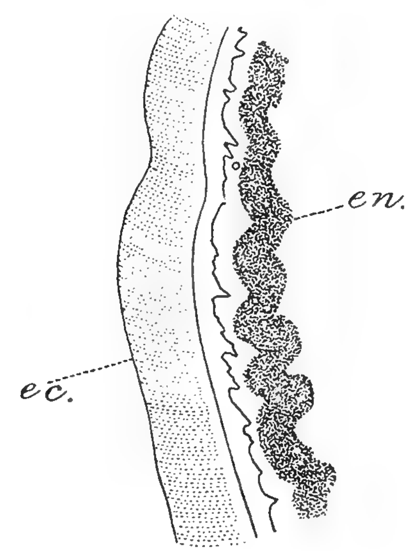

FIG. 2.—*Metridium schillerianum* (Stoliczka).

Vertical section through the sphincter.

ec.=ectoderm: *en.*=endoderm.

When the tentacles are fully retracted the whole of the visible part of the column is smoothly rounded, but as they are extruded a distinct convex ring[1] makes its appearance round the upper extremity. When the oral disk has been completely extruded the column itself contracts strongly both in a transverse and a vertical direction, becoming relatively short and slender. This is due partly to muscular action and partly to the fact that water is expelled from the body-cavity. In the living animal the column in this condition is more or less completely hidden by the tentacles, but if a specimen is bisected vertically a very distinct fold of the body-wall can be seen (pl. vii*a*, fig. 2) some little distance below the base of the tentacles. It is in this fold that the circular muscle of the column is most distinctly strengthened and differentiated.

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[1] See Stoliczka, 1869, pl. x, fig. 6.

Metridium schillerianum has recently been found in great abundance on posts and bridge-piers in canals and creeks of brackish water on the outskirts of Calcutta. In such positions it is often surrounded by sponge-like masses formed of the tubes of a small Sabellariid worm that builds in mud. On one occasion the water under a bridge on the piers of which the anemone occurred had a specific gravity of only 1·006, but individuals from this bridge lived for less than three days in pure fresh water, whereas others placed in water of a much higher salinity flourished.

The species has as yet been found only in brackish water in the Gangetic delta:—at Port Canning on the Mutlah river, in canals and creeks connected with the same system near Calcutta, and in the Hughli at Diamond Harbour. It does not occur in the Chilka Lake, in which suitable conditions are very rarely to be found. Mr. T. Southwell, however, recently took a specimen on a muddy bottom near the edge of the river at Diamond Harbour.[1]

Genus **Phytocoetes**, nov.

The genus may be defined concisely as follows:—

> Thin-walled Metridiinae without a collar, with the column capable of considerable elongation but protean in form, with the basal disk small and unmuscular, never strongly adhesive, with the aboral region capable of assuming a physa-like shape and appearance, with retractile tentacles arranged round the margin of an undivided and non-lobulate oral disk; the tentacles thread-like when fully expanded but highly contractile.

In both the species assigned to this genus the body-wall is very thin in a state of expansion, but can be considerably thickened at any point by the contraction of the circular muscle. This muscle lies on the mesogloea at the base of the endoderm, upon which it does not encroach; it forms a continuous sheath over the whole of the column, but, though uninterrupted anatomically, can be differentiated physiologically into numerous transverse strands almost visible to the naked eye and capable of independent contraction and expansion. When the animal is floating in the water or supported amidst filamentous algae or other similar plants the anterior region of the column is as a rule somewhat narrower than the aboral part, which may be swollen and bladder-like; but when it is at rest in mud, on roots or in sponges, the latter region is strongly contracted and cylindrical while the anterior part is more or less barrel-shaped (pl. vii, fig. 2). In all stages of expansion the basal disk is distinct. If the animal be subjected to abnormal or unhealthy conditions the column may assume almost any form, for the thin muscular walls permit constant and almost instantaneous changes of shape. In one species there is a distinct mesogloeal sphincter, in the other it is absent. The contractions and expansions of the circular muscles cause very great changes in the microscopic appearance of the column-wall.

The tentacles are never very numerous; in one species the normal number is from 48 to 60, in the other 24. In the living animal they sometimes exhibit a

[1] *Cf.* Gosse on *Sagartia troglodytes* in *Actin. Brit.*, p. 95 (1860).

tendency to be arranged in groups, but these groups are never pedicellate. In a state of extreme contraction the individual tentacles may become knob-like, but they are always elongate and very slender when fully expanded.

The walls of the column are either smooth or covered with minute solid tubercles produced by swellings of the mesogloea. The cinclides, which are scattered on the upper part of the column, are conspicuous in the living animal but difficult to detect in preserved specimens. The central part of the column is often encased in a loose sheath of mucus and extraneous particles.

The number of mesenteries is never great. The normal number is 12 complete and 12 incomplete; the latter are almost vestigial, lacking muscle-banners, filaments and gonads. All the complete mesenteries are normally fertile and the species appear to be dioecious. Owing to the presence of large mesenterial stomata (which vary greatly in size, shape and position but are as a rule internal), transverse sections through the stomodaeal region frequently show gaps in the membrane of the complete mesenteries. It is possible, however, that the stomata are capable of almost incomplete obliteration by contraction.

So far as can be judged from published figures,[1] the species of *Phytocoetes* bear a remarkable if superficial resemblance to the aberrant genus *Scytophorus*, but they have no morphological relationship to that genus and have probably been derived, as I have already indicated, from *Metridium* in an environment in which solid objects of attachment are scarce and the bottom is almost uniformly soft and muddy.

The type-species of *Phytocoetes* is *P. gangeticus*, sp. nov.

The genus is only known from brackish water and water of variable salinity on the east coast of India.

Phytocoetes gangeticus, sp. nov.

(Plate vii*a*, figs. 3, 3*a*, 3*b*.)

1907. *Metridium schillerianum* var. *exul* (in part), Annandale, *Rec. Ind. Mus.* I, p. 48, pl. iv.

The animal is colourless in spirit; in life it may be described as being of a pale, translucent greenish flesh-colour. When the tentacles are retracted the uppermost visible part of the column is tinted with olivaceous green, but the retractile region immediately below the oral disk is pale. The tentacles are greenish or yellowish, with a pale purplish tinge due to the presence of algae in the cells of the endoderm; they bear no definite markings. When the column is fully expanded the body-wall is remarkably transparent, especially in the anterior parts.

The column is protean in form, sometimes contracted into a subspherical or barrel-shaped mass, sometimes elongate and almost cylindrical and at least four times as long as wide; in either condition it is frequently divided transversely by clear-cut circular constrictions. Sometimes the aboral region is fully extended and very narrow, while the anterior parts are contracted and broad; often the converse is the

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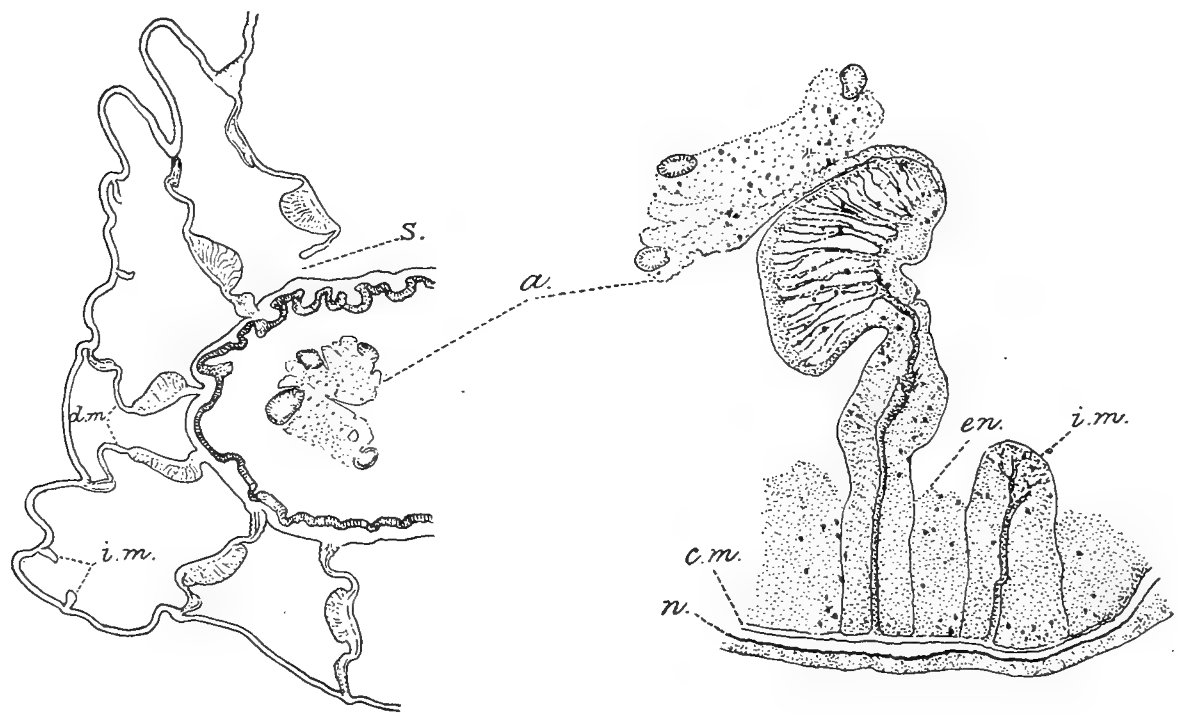
[1] Hertwig. "*Challenger*" *Rep. Zool.*, VI (I), *Actiniaria*, p. 104, pl. iii, fig. 6 (1882).

case. Preserved specimens may have practically any form, except that the basal disk is always narrow and inconspicuous; the aboral extremity as a whole is often swollen and bladder-like. In the living animal, when the tentacles are retracted but the column expanded, the anterior end is cone-shaped, the orifice above the tentacles being closed by a constriction of the column-walls.

Large specimens attain a length of 30 mm.

The tentacles are extensile but rarely or never exceed the column in length; when contracted they are bluntly pointed and minutely annulated; each has a terminal pore. The disk is ample and not at all emarginate. The tentacles are arranged



A. B.

FIG. 3.—*Phytocoetes gangeticus*, sp. nov.

A. Transverse section of column in the upper part of the stomodaeum.

B. Transverse section of a complete and incomplete mesentery in the lower part of the column (more highly magnified).

a. = acontium in section: *c.m.* = circular muscle: *d.m.* = directive mesenteries: *en.* = endoderm: *i.m.* = incomplete mesenteries: *n.* = nervous layer: *s.* = mesenterial stoma.

round its margin. The mouth extends for about three-quarters of the breadth of the disk when the latter is fully expanded, but in some preserved specimens seems to be less extensive. The lips are not prominent, but there are six shallow transverse ridges on each side of the mouth.

The number of the tentacles is very variable; there are usually between 50 and 65; but some as a rule are very small. These small tentacles usually occur together in pairs or groups of three and are situated externally. The normal number of fully developed tentacles is probably 48 or 60.

The basal disk has the generic characters.

The surface of the column is smooth, except for the cinclides. These, though

difficult to demonstrate on the preserved specimen, are conspicuous in the living animal. They are confined to a region separated by a short imperforate "neck" from the disk and otherwise occupy approximately the anterior fifth of the expanded column. They have thin but sometimes rather prominent lips and run across from mesentery to mesentery, but only in the spaces separating complete mesenteries and not always in these. Their arrangement is irregular, but their relation to the mesenteries renders it necessary for them to form vertical rows, which contain from 3 to 7 cinclides each. When the apertures are closed they have the appearance, in the living animal, of fine white transverse lines bridging the mesenterial spaces into which they open (pl. vii*a*, fig. 3*a*).

The stomodaeum extends when expanded for about one-third the length of the expanded column, but can contract independently of the body as a whole. Its walls are not very thick, but the endoderm forms a series of distinct ridges. Transversely, in the sulco-sulcular axis, it is relatively wide, occupying by far the greater part of the diameter of the column; it is, however, strongly compressed.

There are as a rule twelve imperfect, infertile mesenteries as well as the twelve complete ones. Sometimes all of the latter bear filaments and gonads, but in some individuals not more than one-half or two-thirds do so; the incomplete mesenteries are almost vestigial. Owing to the great width of the stomodaeum the directive mesenteries are relatively very short. The basilar muscles are small and feeble and the muscle-banners fairly strongly developed. On the directive mesenteries the latter have in some cases a narrow, elongate form in cross-section, while in others they are shorter and distinctly kidney-shaped. Most mesenteries have a stoma, but this aperture is sometimes absent and when present varies greatly in size, shape and position. As a rule it is very large, of a broad transverse or oblique oval or ovoid form and distinctly internal in position; but sometimes it is much reduced in size and situated nearer the column-wall than the stomodaeum. I have seen one mesentery in which not only was the stoma, which was external in position, very large, but the whole of the membrane between the muscle-banner and the body-wall reduced to a narrow band by a great gap or emargination in the lower part of the mesentery. The band was bounded above by the stoma and below by this gap.

As a rule acontia, which are never well developed, are only present on a few of the mesenterial filaments. The upper trilobed portion of the filaments is short—as a rule shorter than the stomodaeum, and the simple portion relatively long; but the proportionate length of the different parts of the filaments varies greatly even in the mesenteries of a single individual.

The gonads are normal in structure, and as far as I can ascertain the animal is dioecious.

The anterior sphincter is even less differentiated than in *M. schillerianum*, but in carefully preserved expanded specimens which have been rendered transparent, a few folds of the muscle-sheath can be detected in the region occupied by the cinclides. These folds lie in the mesogloea at the base of the endoderm and are not accompanied by any independent muscle-spaces. The rest of the muscle-sheath

resembles that of *M. schillerianum*, except of course that there is no basal disk-sphincter. The walls of the column are for the most part very thin, chiefly owing to a reduction of the mesogloea, in this respect resembling those of the other Gangetic species. In the region of the false physa (fig. 3A, p. 80) the endoderm is, however, greatly thickened.

Types.—Nos. Z.E.V. 6804-6/7, *Ind. Mus.*: from the vicinity of Calcutta.

The species has not been found in the Chilka Lake but occurs abundantly in pools of brackish water at Port Canning in the Gangetic delta and in canals and creeks near Calcutta. In the latter district it was on one occasion found in water of a specific gravity of 1·006.

P. gangeticus is distinguished from *P. chilkaeus*, the only other species as yet known in the genus, mainly by its more numerous tentacles and by the lack of a true sphincter; other differential characters are shown in the table on the opposite page.

At Port Canning *P. gangeticus*, which is markedly gregarious, is found in large numbers ensconced in masses of the sponge *Spongilla alba* that have probably grown round it on the roots of grasses. It is also found in the same pools in deserted burrows of *Teredo* in wooden posts. In both situations it is lightly attached by its degenerate basal disk to foreign bodies. Near Calcutta its favourite situation is among the roots of reeds that grow at the edge of small tidal creeks. Here it is frequently accompanied by masses of the polyzoon *Victorella bengalensis*. Although it is found in small holes in mud, I do not think that the anemone is able to burrow, for in this situation it occurs actually attached to roots and accompanied by the polyzoon, which certainly is not a burrower. In both cases the mud seems to be deposited round the animal; the anemone saves itself from suffocation by elongating its column, while the colonial organism buds freely and so forms a dense mass practically impervious to mud, and is thus able to expand the tentacles of its individuals upon the surface. At Port Canning I have seen an individual of *P. gangeticus* lying exposed in the sun at the edge of a pool. The tentacles were retracted, the orifice above them closed and the column fully expanded owing to the amount of water it contained; in the creeks near Calcutta large numbers of individuals may be found in mud between tide-levels. Very few individuals found in winter are sexually mature; probably the real breeding-season begins about February. The species does not seem to be exclusively nocturnal in habits. In an aquarium healthy individuals often cling to the glass in an upright position by means of the mucus that exudes from the surface of the column. They are able to drag themselves upwards by means of their tentacles as well as to progress in a lateral direction.[1]

Phytocoetes chilkaeus, sp. nov.

(Plate vii, fig. 2; plate vii*a*, fig. 4.)

This species, examined alive, resembles *P. gangeticus* very closely so far as the external characters are concerned, except that it has not more than 24 tentacles

[1] For further details of this mode of progression see *Rec. Ind. Mus.* I, p. 67.

and that almost the whole of the external surface of the column is covered with minute papillae. The internal structure of the two species is also very similar, except that *P. chilkaeus* has a true mesogloeal sphincter situated a short distance below the oral disk. This species is also more sensitive to drugs than its Gangetic ally and therefore much more difficult to preserve in a natural condition. Consequently, preserved specimens of the two look as a rule very different (*cf.* figs. 3 and 4, pl. vii*a*). Those of *P. chilkaeus* are darker in colour, being of a glaucous grey shade, and, owing to the strong contraction of the circular muscles, much more opaque; the column is elongated and cylindrical for the most part and the physa-like appearance of its aboral extremity exaggerated, while the tentacles are reduced to mere knobs, though in full expansion they are as long and slender as those of *P. gangeticus*. The position of the sphincter is clearly indicated externally by a convex annulus (pl. vii*a*, fig. 4).

The specific characters in which the two species differ may be tabulated thus:—

	P. gangeticus.	*P. chilkaeus.*
Tentacles	50–65. Never contracted to mere knobs. Concolorous.	21–24. Liable to be contracted to mere knobs. Sometimes with dark angulate rings and a dark tip.
Surface of column ..	Smooth	Covered, except at the aboral extremity, with minute tubercles and bearing a convex annulus a short distance below the disk.
Sphincter	Absent	Well developed, with elongate muscle-spaces.
Body-wall	Very thin	Much thicker, at any rate in a state of contraction.

The tentacles are normally 24 in *P. chilkaeus*, but one or more may be aborted and I have examined a specimen in which there were only 21. Even in specimens preserved in alcohol the darkening of their tips occasionally persists, though the dark angulate rings disappear rapidly. The markings are due to accumulations of minute algae in the cells of the endoderm. In preserved specimens there appear to be two concentric circles of tentacles arranged alternately, but in the living animal they are distinctly grouped in threes with a single tentacle between each triad. The extreme contraction to be noted in most of our examples took place before death and was apparently due to the fact that unsuccessful attempts were made to paralyse the animals with drugs.

The minute papillae on the surface are produced by swellings of the mesogloea

(fig. 4) and cover the whole of the anterior two-thirds of the column. Towards the posterior extremity they gradually disappear and in some specimens are scanty if not altogether absent between the sphincter and the disk. On the anterior part of the body they are arranged in vertical rows.

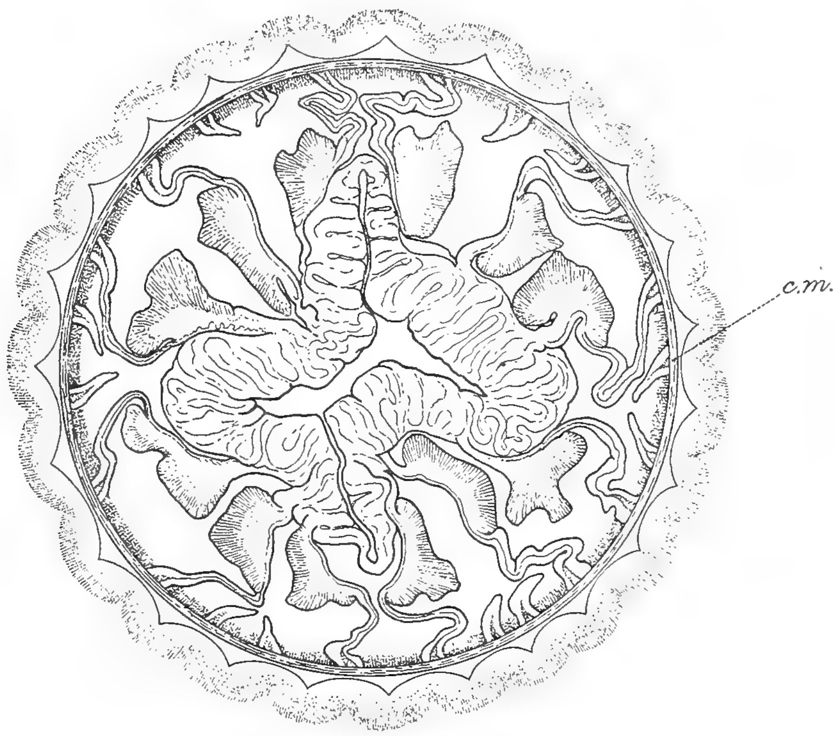


FIG. 4.—*Phytocoetes chilkaeus*, sp. nov.

Transverse section of the column in the lower part of the stomodaeum; from a highly contracted specimen.
c.m. = circular muscle.

The sphincter (pl. vii, fig. 2) consists of numerous strands, most of which are somewhat elongate in vertical section. They are grouped in a band-like figure, usually with a few that are shorter than the rest lying separated in the mesogloea, to which layer the whole muscle is confined. The muscle extends outwards in an oblique direction from near the base of the endoderm into an external annulus produced by a thickening of the mesogloea. The circular muscle-sheath is not interrupted in this region.

The internal structure of *P. chilkaeus* very closely resembles that of *P. gangeticus*. The body-wall appears to be as a rule thicker in the former, but this is due partly to the fact that it is more highly constricted in the specimens examined. When it is not contracted there is comparatively little difference.

Large specimens of *P. chilkaeus*, with the column constricted and elongated, are about 22 mm. in length and 4 mm. in diameter.

Type-specimens. No. 6803/7, Z.E.V. *Ind. Mus.*: from Rambha Bay, Chilka Lake.

P. chilkaeus has as yet been found only in the Chilka Lake, but in both the outer channel and the main area. The only localities in which it was obtained were the head of Rambha Bay and the channel between Satpara and Mahosa. The actual specific gravity of the water in which it was taken varied from about 1·0105 at Rambha to 1·0265 at Satpara. It was collected in January and March.

At Rambha the anemones were found either floating a few inches below the surface or with their aboral disks lightly attached to a filmy alga that grows luxuriantly on mud in very shallow water. Off Satpara they were brought up from a muddy bottom overgrown with weeds in about 12 feet of water. To judge from their muddy bases they had been attached to the roots of the weeds. The aboral extremity was contracted and cylindrical in these specimens, expanded in those from Rambha. The examples from Rambha were taken in January and March;

those from off Satpara in the latter month. At both seasons some individuals were sexually mature. The species is not markedly gregarious.

Genus **Pelocoetes**, nov.

This genus is closely allied to *Phytocoetes* and may be diagnosed as follows:—

Thin-walled Metridiinae without a collar, with a vermiform column, with the basal disk much reduced, with the aboral extremity capable of assuming a physa-like appearance and shape, with the majority of the tentacles arranged in groups each of which is placed on a flattened pedicel or outgrowth from the reduced oral disk; the tentacles slender, thin-walled and not very highly contractile; the oral disk not retractile.

In the structure of its body-wall the single species of *Pelocoetes* closely resembles *Phytocoetes*, but the circular muscle-sheath is even stronger and has a more intimate relationship with the endoderm, with which it interdigitates when highly contracted (pl. vii, fig. 3*b*). Moreover, there is a considerable region on the upper part of the column in which this muscle is to some extent differentiated, being more powerful and more readily thrown into physiologically independent folds than elsewhere and occasionally being associated with a few scattered muscle-spaces. This region does not extend upwards quite as far as the base of the oral disk, but otherwise is approximately co-terminous with the stomodaeum. There is no separate sphincter. The nervous layer of the mesogloea is particularly well differentiated.

The animal lives buried in mud and its vermiform column, plainly correlated with this mode of life, is not so protean as that of *Phytocoetes*.

The tentacles are more numerous than in the allied genus, but variable in number. There is an inner circle of twelve solitary tentacles and an outer circle of twelve pedicellate groups; but the number in each group varies considerably.

The outer wall of the column is for the most part smooth, but bears a certain number of small vesicular swellings on the upper part. The cinclides are arranged definitely in vertical lines on the upper muscular region.

There are more incomplete mesenteries in *Pelocoetes* than in *Phytocoetes*, but fewer than is usual in *Metridium*, the actual number in *P. exul* being 36. None of these are situated in the intramesenterial spaces. Both internal and external mesenterial stomata may be present, but, as in *Phytocoetes*, their size, shape and position are very variable. Speaking generally, the mesenterial filaments are comparatively well developed in *Pelocoetes*; some of the incomplete mesenteries are occasionally fertile; the acontia are long and relatively stout and are normally present on all the fertile mesenteries. The animal is monoecious and protogynous.

The one species known occurs in the Gangetic delta and the Chilka Lake and has been found only in brackish water.

Pelocoetes exul (Annandale).

(Plate vi, fig. 1; plate vii, figs. 3, 3*a*, 3*b*.)

1907. *Metridium schillerianum* var. *exul* (in part), Annandale, *Rec. Ind. Mus.* I, p. 48, etc., figs. 1, 2, 3, 4; pl. iii, figs. 3, 4.

My original description of the "variety *exul*" of Stoliczka's Gangetic Anemone applies for the most part to *Pelocoetes exul* but is vitiated by the fact that I regarded *Phytocoetes gangeticus* as the young of the species now to be discussed. In the actual diagnosis, however, on p. 48 of the paper cited the characters distinctive of what I regarded in 1907 as young and adult individuals respectively are clearly differentiated. All that is necessary now, therefore, in the way of actual description, is to give a fuller account of the tentacular system, which can only be investigated satisfactorily in specimens killed in a fully expanded condition;[1] for the living animal is too sensitive to permit a very detailed investigation, while specimens killed in the ordinary way do not illustrate the peculiarities of the oral disk to anything like the full extent.

The tentacles, as is stated in the diagnosis of the genus, are disposed in a single inner circle of twelve and in twelve external pedicellate groups. The twelve primary internal tentacles represent the twelve complete chambers, each arising above either an inter- or an intramesenterial space, which is continued into its lumen. In the case of the intramesenterial tentacles the base of each occupies practically the whole of the inner part of the roof of the chamber, while in that of the intermesenterial tentacles it is situated opposite the central incompletely separated compartment formed by two of the six incomplete mesenteries that project into the chamber from the column-wall. These primary tentacles do not differ in structure or form from the others.

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[1] I find by far the most satisfactory method of killing these Gangetic species with degenerate basal disks is to allow them to expand themselves fully in a small vessel of water in which natural conditions are so far as possible reproduced. In the case of *P. exul* I fill the vessel half full of mud, make a hole some two and a half inches deep in the mud by thrusting in a pencil, and plant the anemone, basal disk downwards, in the hole. I then leave it until after dark with just sufficient water from its own habitat to allow full expansion of the tentacles. In the evening, after they are fully expanded, I sprinkle on the surface of the water a few crystals of menthol. In the morning the animals are found completely paralysed. Without disturbing them, a considerable amount of commercial formalin (about sufficient to make up a solution of 5% formaldehyde) is poured into the vessel. The whole is left standing for an hour and the specimens are then removed and cleaned. If they are wanted for histological purposes they are subsequently treated with corrosive acetic solution precisely as though they were fresh material. In cool weather at any rate, I do not find that they suffer from this process to any material extent so far as general histology is concerned, but if any delicate cytological work is to be performed it is better to kill them in a contracted condition. The specimens of anemones of which photographs are reproduced on pls. vi and vii*a* were killed and preserved in the way described; it is apparently applicable rather to species with very thin muscular walls than to ordinary fixed forms, and I have not found it altogether successful in the case of *Metridium schillerianum*. In that of *P. chilkaeus* it failed, possibly on account of the use of too much menthol.

There are two pedicellate groups, alternating with the single tentacle, above each complete intermesenterial space; each group is associated with one complete and three incomplete mesenteries and its lumen is continuous with that of three incompletely separated compartments; one of its internal walls is practically co-terminous with a complete and the other with an incomplete mesentery, while the upper extremities of two other incomplete mesenteries are continued into it. The pedicel itself is a hollow process of the margin of the oral disk; its length is considerably greater than its breadth; it is compressed from above downwards; it has parallel sides. At some little distance from its point of origin the process bifurcates in a horizontal plane and just within the fork a single tentacle, which we may call the furcal tentacle, arises on the upper surface. Each branch of the pedicel bears two, three or four tentacles; the number is variable, sometimes even on the disk of a single individual.

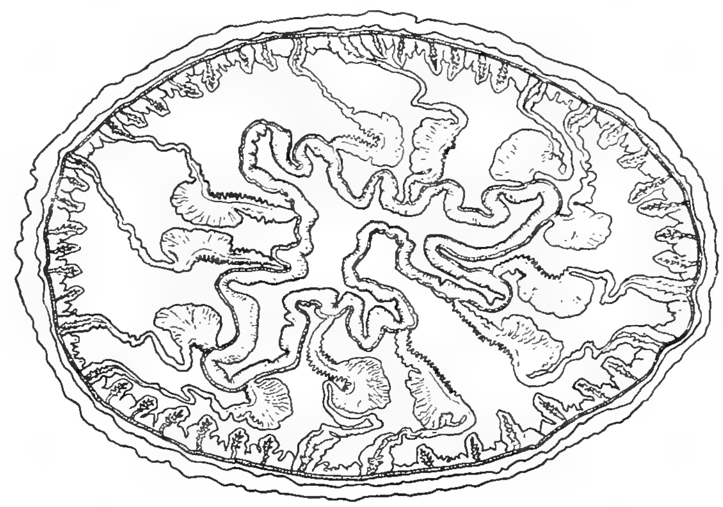

FIG. 5.—*Pelocoetes exul* (Annandale).

Transverse section of the column in the muscular region, from a highly contracted specimen.

In the lower or posterior wall of the pedicel there are, projecting into its lumen, four muscular ridges, two practically at the lateral margins and two in the middle. These ridges are actual prolongations upwards and outwards of the four mesenteries with which this process is associated; above and opposite each of them on the upper or anterior wall a similar ridge is developed, so that the whole lumen is divided incompletely into three chambers, the two outer pairs of ridges being close to the sides of the pedicel. The separation is incomplete because the united depth of the two ridges of each pair is not so great as that of the lumen. The furcal tentacle is produced at the distal extermity of the central chamber, while each of the lateral chambers corresponds to one branch of the pedicel. The number of tentacles developed on each branch is evidently a matter of secondary importance.

Although one of the lower ridges in each pedicel is connected with a complete mesentery while three are continuations of incomplete mesenteries, no difference in structure can be observed; nor is there any difference between these lower ridges and the corresponding upper ones.

The walls of the pedicel and of the tentacles are very thin, the mesogloea and the circular muscles being poorly developed in them. The longitudinal muscles, though by no means thick are, in spite of the non-retractile and not highly contractile state of the disk, well developed. The mesenteries closely resemble those of *Phytocoetes*, except that there are 36 instead of 12 incomplete mesenteries and that the filaments are more uniformly developed on the complete ones.

In the case of *Phytocoëtes* the difference between the microscopic appearance of the

body-wall in specimens in which the circular muscles are contracted or relaxed has already been noted (p. 78); in *Pelocoetes* it is even more marked. When the column is fully expanded the total thickness of the wall is reduced to about 0·02 mm. and the mesogloea is a mere thread even under high powers, whereas in examples killed with these muscles contracted the wall is about 0·17 mm. thick and the mesogloea, including the muscle-band, 0·028 mm. thick.

If the muscles are at all contracted there is always a tendency for the column of *P. exul* to assume an oval form in cross-section and this feature may be observed to some extent even in the living animal; the main axis of the section is sulco-sulcular (fig. 5, p. 87).

The types of the species, which are from Port Canning, are numbered Z.E.V. 2419-21/7 in the books of the Indian Museum.

P. exul has been found only in small pools of brackish water at Port Canning in the Gangetic delta and in the main area of the Chilka Lake, but its habits render it very difficult of detection and capture and it is actually, in all probability, distributed more widely than we know. In the lake it was taken close inshore at Rambha in a few inches of water in January and off Kalupara Ghat in the northern part of the area in very shallow water in April. The salinity of the water is not precisely known, but the specific gravity must have been between 1·005 and 1·010.

This anemone lives, as already stated, buried in the mud up to the base of its oral disk, which can be pulled downwards with great rapidity on disturbance. It is nocturnal in habits to this extent—the tentacles are never fully expanded by day and remain with their tips extending from the hole in the mud for a short distance only, whereas by night they are completely extended. These facts were observed in the case of anemones *in situ* at the edge of the lake in January. A bright light directed on the disk, however, did not cause contraction. Although in early life the animal must be an active burrower as it lives in a vertical burrow several inches deep, adults are very helpless when removed from their proper environment and show no inclination to make a fresh hole. Their vermiform column prevents them from assuming an upright position, and it is very difficult to keep them alive in captivity unless they are literally planted in mud in the way described in the footnote on p. 86. Further particulars as to the habits of *P. exul* will be found in my paper of 1907.

In specimens taken in the Chilka Lake in January the ovaries were mature; this was also the case with specimens taken at Port Canning in December; but in others taken at the latter locality in January it was the testes that were ripe.

Family EDWARDSIIDAE.

1905. Edwardsiidae, McMurrich, *Zool. Jahrb.*, Suppl. VI (III), p. 218.

Remarkably few species of this family have been found in the warmer seas and the occurrence of two genera, representing respectively the *Edwardsia* and the *Halcampa* sections of the family, in a locality so peculiar as the Chilka Lake is therefore noteworthy.

Genus **Halianthus**, Kwietniewski.

1896. *Halianthus*, Kwietniewski, *Jena. Zeitsch. Naturwiss.* XXX, p. 585.

The species hitherto assigned to this genus are mainly Arctic, but McMurrich (*op. cit.*, 1905, p. 223) has described one from the Pacific coast of South America. I can find no previous record from the Indian Ocean.

Halianthus limnicola, sp. nov.

(Plate vi, fig. 2; plate vii, figs. 4, 4*a*, 4*b*.)

When at rest the living animal has a conical shape, slightly swollen in the middle region and slightly constricted at the truncated end, *i.e.* just below the oral disk. The aboral end is bluntly pointed and often not at all inflated; externally there is no apparent separation of capitulum, scaphus and physa, but the last is to some extent retractile. The body can assume practically any shape from spherical to cylindrical and sharp constrictions at one or more points are often a noticeable feature of preserved specimens; when the tentacles are retracted the upper part of the column assumes a subspherical form, while the aboral region is constricted into a cylindrical peduncle; or the whole organism may have an elegant vase-like outline. There is no external cuticle or sheath.

On the external surface there are twelve longitudinal rows of relatively large, though not very prominent, solid tubercles, which correspond roughly in position with the twelve mesenterial spaces; they are mainly due to thickenings of the mesogloea. Towards the aboral extremity these rows, and also the individual tubercles, tend to become obsolete. The whole of the body-wall and the wall of the disk and tentacles is hyaline and practically colourless, but the tentacles are often ornamented on the upper surface with V-shaped translucent bars and the disk is not so transparent as the column. The mesenterial filaments and the gonads are of a bright yellowish flesh-colour, which is communicated by reflection to the remainder of the animal, especially in a state of contraction. Specimens in spirit or even formalin become more or less opaque.

The oral disk is ample, its outline in contraction is broadly oval, the longer axis being that of the mouth, which occupies the greater part of the disk in this axis. The lips are by no means prominent when the mouth is closed; there are six low transverse ridges at each side. The normal number of tentacles is twelve, but occasionally one or more subsidiary tentacles are produced asymmetrically; the normal arrangement is that the tentacles form two concentric circles of equal numbers and alternate round the margin. There is no structural difference between ordinary and subsidiary tentacles; both when fully expanded are stout, cylindrical and blunt and hardly longer than the longer diameter of the disk; they can be contracted into little wart-like projections. The disk is usually flat but can assume a conical or even a clavate form.

The aboral extremity is perforate, but the pore is always small.

Our largest specimens, which have shrunk very little, are about 5 mm. long.

The circular muscle of the body-wall is well developed and in the living animal can be detected readily with the aid of a hand-lens as a series of transverse rings capable of independent contraction and expansion. The differentiation is, however, physiological rather than anatomical and in vertical sections the muscle forms a continuous sheath of minute fibres, having the general appearance of an irregularly serrated line more conspicuously folded at some points than at others. In transverse sections the fibres lie at the base of the endoderm (as of course they do also in vertical sections) but run across the mesogloea at the base of the mesenteries. The muscular sheath is most strongly developed in the wall of the physa.

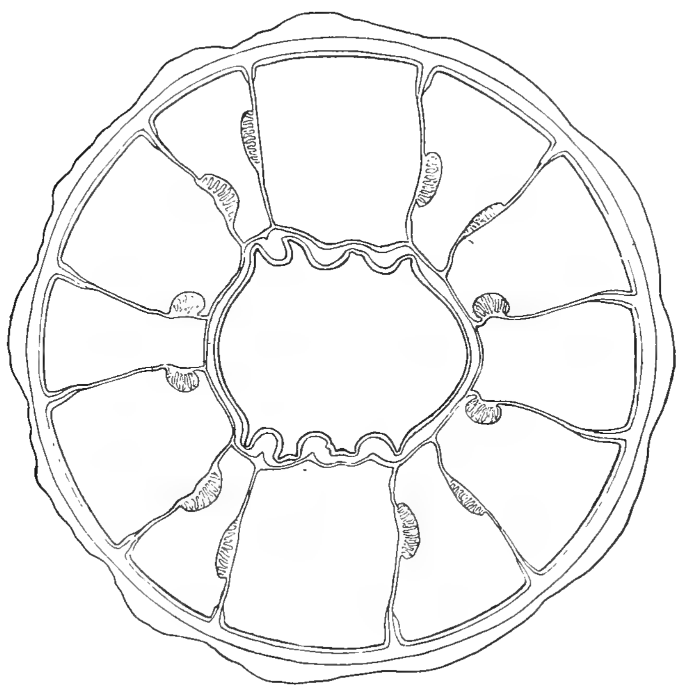

FIG. 6.—*Halianthus limnicola*, sp. nov.

Transverse section of the column in the middle of the stomodaeum.

The sphincter (pl. vii, fig. 4) is well developed but short. It lies close below the base of the tentacles and consists of a number of relatively stout isolated strands surrounding distinct muscle-spaces and well separated by mesogloea from the muscle-sheath.

The stomodaeum is spacious in cross-section; the walls, which are moderately thick, are thrown internally into three distinct though not very deep folds on either side; the sulcus and sulculus are very broad. The sulco-sulcular length in a state of expansion occupies a little less than a half of the width of the column.

There are no rudimentary or incomplete mesenteries. The twelve complete mesenteries are normally fertile. The kidney-shaped muscle-banners are moderately small and separated by some little distance from the wall of the stomodaeum; they contain a considerable number of moderately long and slender folds of the mesogloea. The parietal muscles are slightly and irregularly folded, the projections of the mesogloea on which they are based being by no means clearly defined in sections.

The gonads are normal in structure and not very much folded transversely. The animal appears to be dioecious.

The specific characters of *Halianthus limnicola* may, therefore, be summarized as follows:—

(1) The whole animal (except the internal organs) is colourless and translucent or hyaline, the markings on the tentacles being due to relative degrees of transparency and not to pigmentation.

(2) The normal shape of the column is conical and there is no external differentiation of capitulum, scaphus and physa.

(3) There is no external sheath or cuticle.

(4) There are twelve vertical rows of solid tubercles on the column.

(5) The tentacles are normally 12 in number, but extra subsidiary tentacles are sometimes produced asymmetrically; both the normal and the subsidiary tentacles are (even when fully expanded) stout, blunt and hardly longer than the longer diameter of the disk.

(6) The mouth is relatively wide.

(7) The stomodaeum is spacious, its sulco-sulcular axis occupying nearly one half of the diameter of the column.

(8) The muscle-banners are small, though not so small as in some forms, and separated from the walls of the stomodaeum.

(9) There are no incomplete mesenteries.

(10) The parietal muscles are feebly developed and accompanied merely by somewhat indistinct projections of the mesogloea.

Types. No. Z.E.V. 6032/7, *Ind. Mus.*

This species has been found as yet only in the Chilka Lake, in the main area of which it is abundant at all seasons except the end of the rains; it is also found, much more sparingly, in the muddy parts of the outer channel. It is commonest in from 6 to 12 feet of water and has been found throughout the range of salinities occurring in the lake.

Halianthus limnicola is gregarious, and was usually taken on a muddy bottom in which there was a fairly large admixture of dead Lamellibranch shells. It is very active and not at all shy. When removed from the water or otherwise disturbed it retracts its tentacles instantaneously but extrudes them again the moment that it is comfortable. In a vessel half filled with mud and shells and half with lake-water it begins to burrow almost immediately. This it prefers to do among shells, among which it progresses in an almost horizontal direction, lying prone and dragging itself along with fair rapidity by means of its tentacles. Their movements are accompanied and assisted by rhythmical longitudinal expansions and contractions of the column. No rhythmical transverse contractions of the column were observed, but constrictions often appeared suddenly at different points. The animal has a strange habit of alternately retracting and extruding the proximal part of the physa. No attempt was made to form an external sheath or cuticle, the transparent wall of the column remaining remarkably clean. If left to itself the anemone sometimes formed a vertical burrow, in which, however, it never remained for very long. The muscular nature of the physa would suggest that it is employed in making burrows of the kind, but the process was not observed.

Although numerous individuals of the species were obtained in most hauls of our nets on suitable ground throughout the greater part of the year (even in July, when the rains were established, and in September, when the water had become fresh), yet in November it was found to be very scarce and only a few specimens were obtained. These were, moreover, in a quiescent condition, exhibiting none of the normal muscular activity, and were so contracted and shrivelled that they could not at first

be identified. There can, therefore, be little doubt that prolonged exposure to fresh water has much the same effect as it has on the medusa *Acromitus rabanchatu* (p. 101, *postea*). A larger proportion of the actinians, however, probably perish and the physiological changes are produced more slowly.

H. limnicola does not seem to have any fixed breeding season, for individuals were found with apparently ripe gonads at all times of the year, even in November.

Genus **Edwardsia**, Quatrefages.

1889. *Edwardsia*, Haddon, *Trans. Roy. Dublin Soc.* (2) VI, p. 326.
1895. ,, Faurot, *Arch. Zool. expérim.* (3) V, p. 108.

Edwardsia has been generally regarded as characteristic of temperate seas both north and south of the Tropics, and I can find no reference to any undoubted species from the Indian Ocean. Carlgren[1] has examined a representative of the closely allied genus *Edwardsiella* from the Red Sea and East Africa, which was originally described by Klunzinger[2] under the name *Edwardsia pudica*, and thinks that *Edwardsia adenensis*, Faurot[3] from Aden is probably a synonym. *E. arenosa*, Klunzinger, is also an *Edwardsiella*.

Edwardsia tinctrix, sp. nov.

(Plate vi, fig. 3; plate vii, figs. 5, 5*a*; plate vii*a*, fig. 5.)

When fully extended the whole animal is vermiform, and narrowly sausage-shaped when the capitulum is introverted. The distinction between capitulum, scaphus and physa is well marked in the former condition and that between the two last regions in the latter. The scaphus is relatively long and slender, the capitulum, which is not constricted, short. The naked physa is also short, but not so short as in some species, it has a rather narrow ovoid form when expanded and bears at the tip a circle of eight minute finger-shaped processes. These, however, are apt to disappear in preserved specimens and in any case are so small that they can only be seen under a high power of the miscroscope; in structure they are solid outgrowths, mainly of ectoderm and containing a large number of minute intracellular refractive granules. On the scaphus there are eight vertical rows of small but prominent mamilliform tubercles corresponding in position to the eight mesenterial spaces. The structure of these tubercles will be discussed presently. Not only the whole of the capitulum but also a considerable part of the scaphus can be introverted.

The sixteen tentacles are long, slender and pointed. The oral disk is narrow but more or less tumid; the mouth runs across the greater part of it. The tentacles are not very highly contractile, but can be thrust into the mouth so far that their tips extend into the physa.

The capitulum, with the disk and tentacles, is translucent and often colourless,

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[1] *Mitt. Naturh. Mus. Hamburg*, XVII (2), p. 46 (1900).
[2] *Die Korallthiere des Rothen Meeres* I, p 81, pl. vi, fig. 3.
[3] *op. cit., supra*, p. 121.

but is usually tinged more or less deeply with olive-green; sometimes the endoderm of the tentacles is marked with alternate green and white rings, the pale rings being narrower than the dark. The most characteristic features in the colouration is, however, a series of eight blackish vertical bars that ornament the capitulum just below the disk, one outside each mesentery. Each bar is double, being completely bisected longitudinally by a colourless or pale line, and expands at the upper end, which is sometimes separated as a distinct spot or rather pair of spots. The scaphus has a bright orange-scarlet colour, which, unlike the markings of the capitulum, retains its intensity in spirit; this colour is not intrinsic in the tissues of the animal but due to a staining of the particles of mud incorporated in the delicate "cuticle" that clothes the scaphus.[1] The physa, both in living and in preserved specimens, is of a fairly opaque white.

The tubercles on the scaphus are a characteristic feature of the species, not only on account of their prominent nature but also of their internal structure. In most sections of the column they appear merely as hollow outgrowths of the wall due mainly to a thickening of the mesogloea accompanied by the apparent formation of a large lacuna; but if specimens of the whole animal be mounted for microscopic examination after being rendered transparent it will be readily seen that each lacuna contains, in addition to a quantity of mucus, what appear to be a number of long slender chaetae arranged for the most part almost at right angles to the circumference of the column but converging somewhat to the tip of the papilla, which contains a minute aperture. In a few sections of several large series some of these peculiar bodies remain *in situ* and can be recognized in the slender nematocysts of the type figured more than fifty years ago by Gosse in his *Actinologia Britannica* (pl. xi, fig. 10, 1860). Their threads can be occasionally detected emerging from the pore in the papilla (pl. vii, figs. 5, 5*a*). The cavity of the tubercle has a diameter of about 0·09 mm.

The body-wall is very thin in the capitulum, but considerably thicker in the scaphus, the difference lying mainly in the relative amount of mesogloea present; in the physa the mesogloea is thin but the endoderm rather thick. There is no special sphincter, but the circular muscle, which lies at the base of the endoderm, is well developed both in the scaphus and in the physa. The nervous layer is well developed. The wall of the tentacles is thick, but their mesogloea relatively thin.

The stomodaeum is ample at its upper extremity, occupying in its longer axis more than half of the diameter of the column and having a rather narrowly oval shape in cross-section; it is very short vertically and does not quite reach the lower end of the capitulum.

There are, in addition to the usual eight complete mesenteries, eight rudimentary ones, but these are confined to the upper part of the stomodaeum. They have the arrangement apparently normal in the genus, *i.e.* there are two in each sulco-lateral

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[1] A similar staining of muddy particles is often produced at the edge of the mantle in some of the Chilka Lamellibranchs (*e.g. Theora opalina*) and in the tubes of Maldanid worms.

chamber and one in each of the other chambers except the sulcar and sulcular. Most of these rudimentary mesenteries consist merely of the basal (parietal) longitudinal muscles and the folded mesogloea that supports them, but those in the sulcolateral chambers are distinctly better developed and possess a rudiment of the

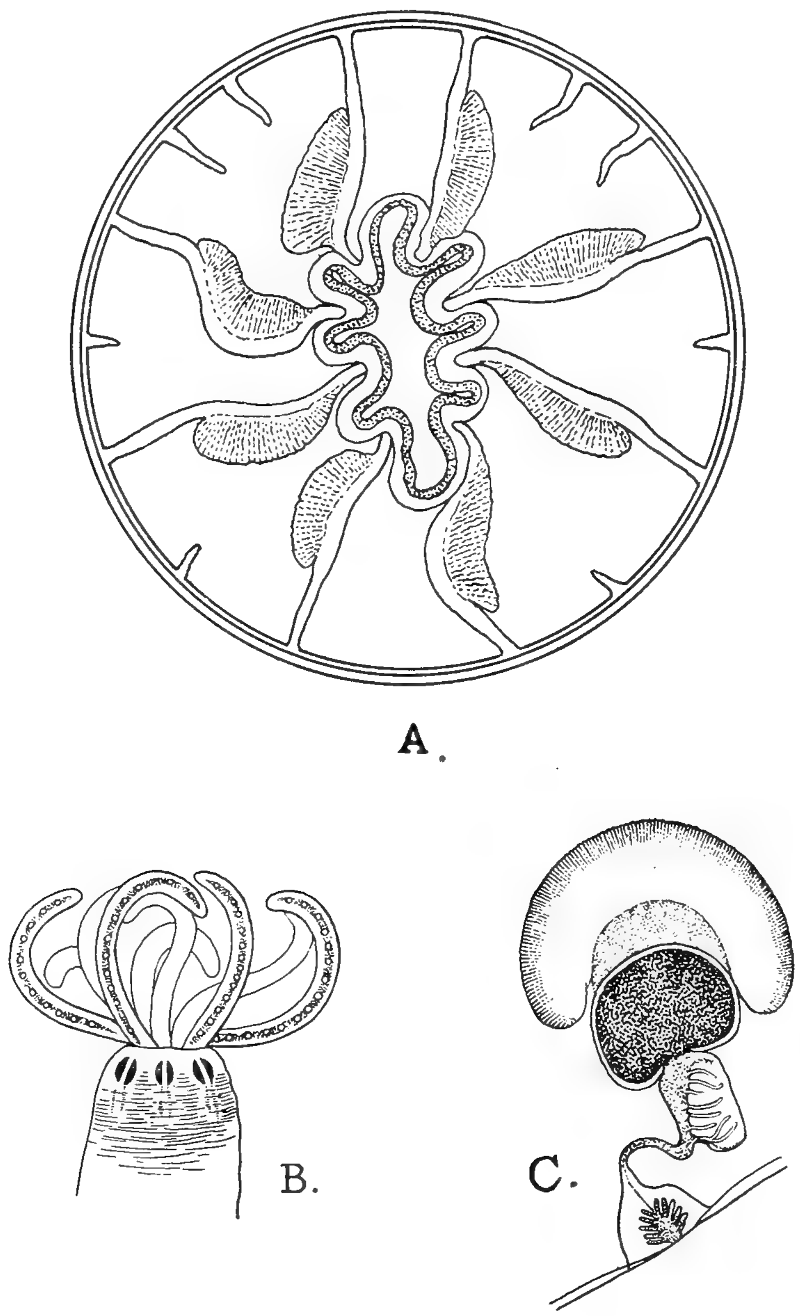

FIG. 7.—*Edwardsia tinctrix*, sp. nov.

A. Lateral view of the capitulum (from a sketch by Mr. G. Henry).
B. Transverse section through the upper part of the capitulum.
C. Transverse section of a fertile male mesentery through the upper end of the gonad.

membranous part as well; indeed, they are at least as well developed as the incomplete mesenteries of *Phytocoetes*.

The longitudinal muscles of the complete mesenteries differ in different regions of the column. In the upper part of the capitulum the parietal series are poorly developed, whereas the muscle-banners are large and powerful, occupying the greater

part of the width of the mesentery (fig. 7A, p. 94). A little lower down these latter structures become much thinner and weaker, practically disappearing at the lower end of the stomodaeum, while the parietal muscles become better developed. Below the stomodaeum the muscle-banners again become large. The mesogloea in the basal part of each mesentery is thrown on each side into five or six folds, all of which are moderately stout and have an approximately similar form and depth.

The gonads are normal and the animal is apparently dioecious.

Our largest specimen of this species is about 30 mm. long in a fully extended condition, the greatest transverse diameter of the scaphus being 3 mm. and the length of the tentacles 6·5 mm., but this specimen is unusually large.

Types.—No. Z.E.V. 6819/7, *Ind. Mus.*

The most important specific characters of *Edwardsia tinctrix* lie in the shape and colouration of the column, the presence, peculiar structure and comparatively large size of the tubercles on the scaphus, the relative length of the sulco-lateral rudimentary mesenteries, the form and relative size of the longitudinal muscles of the mesenteries and the proportions of the stomodaeum; but in the identification of specimens of the genus attention must be paid to the general sum of characters rather than to separate features or to single organs or parts. Perhaps the most peculiar feature of the Chilka species is the structure and size of the tubercles, but those of *E. claparedi* (Panceri) are probably similar, if relatively smaller, for the nematocysts in these organs are very liable to disappear from sections.[1]

E. tinctrix is, for the greater part of the year, one of the most abundant members of the fauna of the main area of the Chilka Lake, over the whole of which it occurs from the shore to a depth of 16 feet; in the muddy parts of the outer channel it is much less common. It was found in water of which the specific gravity varied from that of the Bay of Bengal at the time to that of pure fresh water. Outside the Chilka Lake it has not yet been discovered.

The anemone lives buried in mud as far as the base of the disk. It is extremely shy and sensitive. When removed from mud individuals almost invariably have the disk and capitulum introverted into the scaphus, and it was not found possible to cause them to expand by daylight. If planted in mud covered with water in a glass they often did so by night[2], but even then showed no tendency to shift their position or to construct fresh burrows for themselves.

E. tinctrix is much less common in the Chilka Lake at the end of the rains than at other seasons, but a few individuals were found even in November. They were much contracted and did not expand in captivity even at night. It is probable, therefore, that they are affected by long-continued residence in fresh water much in the same way as *Halianthus limnicola*.

In specimens taken between March and July inclusive the gonads were ripe, as

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[1] See Walton and Rees, *Journ. Mar. Biol. Ass. Plymouth* X, p. 64, fig. 2, 1913.

[2] Walton and Rees (*op. cit.,* p. 62) found that an individual of *E. claparedi* (Panceri) at first refused to expand by daylight but after a time did so.

they were occasionally in September; but this was not the case in those collected between November and February.

SCYPHOMEDUSAE.

(Plate vi (in part); plate viii.)

The only medusa of this group found in the Chilka Lake belongs to the order Rhizostomata and the division Triptera. The species is here described as new and belongs to a genus recently discovered in the Philippines, in which the only form hitherto recognized occurs. The Chilka species is of considerable biological interest, not only because it has been able to establish itself as a permanent resident in water of very variable salinity, but also because we found it possible to estimate the direct effect of fresh water upon the physiology of individuals (p. 101, *postea*). Some post-larval forms were obtained and are here described briefly and figured; they throw light on the evolution of the Rhizostomatous mouth-arm. The species is also common in the Bay of Bengal.

Order RHIZOSTOMATA.

Division *RHIZOSTOMATA TRIPTERA.*

Genus **Acromitus**, Light.

1914. *Acromitus*, Light, *Philippine Journ. Sci.* (D) IX, p. 210.

This genus has recently been described to contain a single species (*A. maculosus*, Light) from the Philippines. Its most striking diagnostic character is the possession at the tip of each mouth-arm of a single greatly elongated tentacle-like filamentous process. This process is very much longer and stouter than the small sensory filaments scattered among the mouths on the arms.

In describing a new species from the Chilka Lake and the Bay of Bengal I have closely followed the descriptions of representatives of the order published in Meyer's *Medusae of the World* (1910). In all the features accepted by Light (1914, *op. cit.*) as of generic importance this species agrees with *A. maculosus*, the only other member of the genus yet known.

Acromitus rabanchatu [1], sp. nov.

(Plate vi, figs. 4-6; plate viii.)

The disk is no flatter, at any rate in living medusae and in specimens recently preserved in formalin, than a hemisphere. In large individuals its diameter is as

[1] *Raban-chatu* is the vernacular name given to this medusa by the Uriya fishermen of the Chilka Lake, who would probably apply it also to any other medusa of similar shape. It means "the umbrella of Ravana", the demon-king of Ceylon who plays the part of chief villain in the *Ramayana*.

much as 20 cm. The exumbrella is smooth to the naked eye, but under the microscope appears minutely granular, each granule consisting of a little prominence beset with nematocysts. There are eight rhopalia, each flanked on either side by a small, elongate, tapering marginal lappet. A furrowed exumbrellar pit extends inwards down each rhopalium; as seen from above the outline of the pit is somewhat expanded towards the margin and constricted inwards. The rhopalar lappets, which are longer than the others, are not expanded inwards at the base and do not meet at any point. The velar lappets, of which there are four pairs in each octant, are short and broad; their tips are very broadly rounded or subtruncate, and the incisions that separate them short, those separating the two lappets that form a pair being shorter than those that separate one pair from another. There are thus 16 rhopalar and 64 velar lappets, or 80 in all.

The width of the arm-disk at its base is about two-thirds, and at the point at which the arms originate from it about one-half that of the bell.

There are four narrow genital ostia, each a little narrower than the pillar which separates one ostium from the next. Each is constricted below by a thick, wide, gelatinous process of the bell-disk, and a little distance outside each a broad triangular process with a bluntly pointed tip is directed downwards and inwards from the subumbrellar surface. It occupies a position immediately below one of the rhopalar canals. The arm disk is very slightly emarginate in each perradius. The subgenital cavity is broadly cruciform.

At their bases the eight mouth-arms are joined together in a circle for a short distance. Their relative length is somewhat variable and one or more, perhaps owing to accident, are sometimes shorter than the others; they are always comparatively long in proportion to the vertical axis of the bell. The lower, bifid portion of each arm occupies about four-fifths of its total length. In this region the mouths are arranged in a single row down each margin of each edge of the three lamellae. On the upper, simple part of the arm they extend up the inner edge, in the same formation, to its point of origin. The fringed lips, however, are so contorted, and the minute capitate stinging-tentacles so numerous upon them, that it is difficult to make out the precise arrangement without studying immature medusae. Normally the arm is bluntly pointed at the tip.

The sensory filaments on the sides of the arms are short, slender and bluntly pointed; they are often entirely concealed among the capitate tentacles and seem to be much better developed in some individuals than in others. Their arrangement is not very regular, but, generally speaking, they are set in short transverse lines parallel to and alternating with the mouths. The elongate terminal filament characteristic of the genus is rather stout at the base and tapers gradually. When fully formed it is of great length, but it is rarely well-developed on all the arms of an individual and may be altogether absent from some. This is probably due to accident, for the tip of the arm itself is sometimes lacking. Not infrequently the filament has one or more short branches at its base. Possibly this is due to regeneration after injury.

The stomach is cruciform. There are eight rhopalar and eight adradial canals. The former reach the broad zone of anastomosing circular canals externally, but the latter are usually separated therefrom by an inwardly projecting portion of this peripheral system. Even in adult medusae an adradial canal can sometimes be traced in a straight line through this projecting portion to the outer zone, but more frequently it loses its identity on entering the former. The gastric filaments are numerous but very small. They are short, cylindrical and bluntly pointed.

The colour of the bell, arm-disk and arms is milky white, neither transparent nor altogether opaque. As a rule the bell is ornamented with dark spots, but their size, number and arrangement are variable, and often they are absent. Sometimes (perhaps most frequently) there is a broad immaculate peripheral zone and the spots, which are about 2 mm. in diameter, are densely scattered over the remainder of the bell; but sometimes they extend outwards to the marginal lappets, and I have seen medusae, apparently quite uninjured, in which there were only some half a dozen minute specks on the central part of the dome. Sometimes the spots are rather large and fewer than usual; I have examined one individual in which they ran together to form large irregular blotches on the margin. The pigment appears, in the living medusa, almost black to the naked eye, but if the animal is allowed to die in water it streams out in a deep purple cloud. In spirit or formalin the spots fade to a reddish brown and gradually, after some months, disappear altogether. The gastric filaments and the gonads are naturally of a yellowish flesh-colour, but fade immediately to opaque white in spirit or formalin.

Type.—No. Z.E.V. 6740/7, *Ind. Mus.* Preserved in 5 % formol.

Distribution.—This medusa is common in shallow water on both sides of the Bay of Bengal and in backwaters in the Madras Presidency. I have examined specimens from the coast of Tenasserim and of Orissa. In the Chilka Lake it occurs at all times of the year both in the outer channel and in the main area. We found it in water of every degree of salinity up to that normal in the Bay of Bengal, and even in pure fresh water; it evidently breeds in brackish water. The effect of fresh water upon it is discussed below (p. 101).

Acromitus rabanchatu is closely allied to the type-species of the genus (*A. maculosus*, Light[1]), from which it differs in colouration, in having the velar lappets shorter and blunter than the rhopalar, the terminal arm-filaments stout and tapering at the base, in the shape of the rhopalar pits and rhopalar lappets and in several other minor characters.

Young stages.

Many small specimens were obtained in tow-nets, especially in November, 1914 in the immediate neighbourhood of Barkuda Id. The smallest are about 3 mm. in diameter and represent an interesting stage in the development of the species. Practically every other stage up to the full-grown medusa is represented in our collection.

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[1] *Philippine Journ. Sci.* (D) IX, No. 3, pp. 210–216, figs. 4–6 (1914).

In our smallest specimens the disk is flat and membranous, with only a slight convexity in the central region of the exumbrella. The margins can, however, be everted upwards so that the structure becomes deeply concave, resembling a chalice in form (fig. 8). The muscular system is poorly developed and that of the canals is still in a primitive condition. The sixteen radiating canals are well developed, but they open outwards directly into a circular canal on the periphery. The walls of the latter canal are irregular in outline and somewhat indefinite projections can already be detected, representing the anastomosing channels that will be developed later. The actual margin is so delicate that it is invariably injured in specimens taken in a tow-net, but the rhopalar lappets are relatively large and conspicuous and the velar lappets short and broad and perhaps not very clearly separated. There appear to be four in an octant. The actual rhopalia are well-developed, but the furrowed pit above them is represented only by a slight depression in the exumbrella.

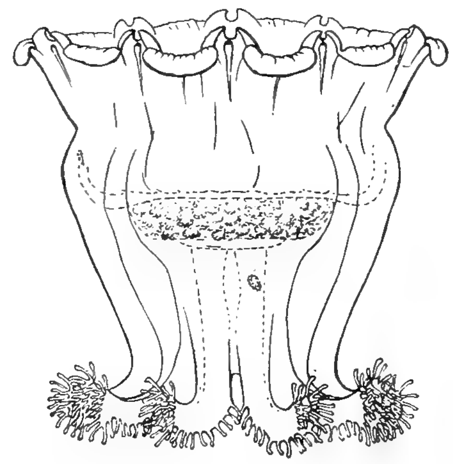

FIG. 8.—*Acromitus rabanchatu*, sp. nov.

A very young medusa with the bell everted upwards.

The most interesting features of these young medusae are to be found in the mouth-arms. The arm-disk has already assumed its final shape, but the ostia are relatively smaller than in the adult and are not protected by depending processes of the subumbrella. These processes do not appear until a much later stage in post-larval development is attained, and the ostia remain relatively small until the bell is considerably larger. In the smallest specimens the arms themselves (pl. viii, fig. 2) are still in the Semostoman stage and may be compared with those of the adult medusa in *Aurosa*. They are united in a circle at their base to a slightly greater relative extent than in the adult, to form what may be called a short manubrium, and are arranged in four pairs. Each arm is an elongate, membranous, flattened process of the margin of this manubrium, bilobed at the distal extremity and having the tips of the lobes slightly everted. The lobes are rounded and do not diverge widely. The inner (endodermal) surface is concave and a single row of minute capitate tentacles run round the whole arm (including the lobes), and also along the margin of the manubrium between the bases of the members of each pair of arms. The tentacles are least numerous in the latter position.

It would be out place to discuss the post-larval development in any great detail, but one or two points of general interest may be noted. It may be stated firstly that there appears to be very little correlation of a definite kind in the origin or full elaboration of different organs in different individuals. In some very small specimens the canal-system is already more elaborate than it is in others of much larger size; the bell is much deeper, and has a shape more near that of the adult, in some young examples than it has in others of more advanced development as regards the canal-system; the terminal filaments of the arms rarely appear at the

same time on all the arms of the same medusa, and are frequently absent in individuals of later growth than in some of those in which they are fully formed; the lateral sensory filaments of the arms usually appear later than the terminal ones, but can sometimes be detected in the form of minute buds before the latter make their appearance.

A second point of interest lies in the fact that in the development of the canal-system the inward projections of the peripheral plexus connected with the adradial canals first make their appearance as irregular processes of the primitive circular canal and are in no way connected with the radiating channels. Each projection is formed in two halves, one half on each side of the canal with which the whole is ultimately to fuse. Even after the two halves have become joined to the two sides of the radiating canal, it runs straight through them and maintains its identity to the margin of the disk. This condition prevails for a considerable period and may occasionally be found persisting as an abnormality in one or more octant of a large medusa.

But the most interesting feature of our series of young specimens of *Acromitus* lies in the clear manner in which it illustrates the evolution of the Rhizostomatous mouth-arm (plate viii, figs. 2 to 3*b*). The peculiarities of the structure of this organ are due in the first instance to unequal growth in its different parts. The everted terminal lobes of the arm of the young medusa grow more rapidly than the simple basal part, and the margins in both regions grow more rapidly than the middle portion. The first consequence of the accelerated growth of the terminal lobes is that the whole arm is definitely folded inwards along the middle line, while the fact that the margins become longer than the middle region causes them to be thrown into a series of short transverse pleats. This double folding causes certain parts of one side of the arm to be brought into close contact with the corresponding parts of the other side, and also certain parts of each margin to be pressed against others on the same side; but prevents the whole of one vertical half coming into contact with the whole of the other. In fact, a central vertical canal is left open down the mid-ventral line of the primitive arm, while lateral canals of smaller calibre diverge from it obliquely to the margin on either side. The whole figure thus formed is pinnate. Simultaneously with the production of this system of canals a great increase in the bulk of the mesogloea of the arm takes place. Where endoderm meets endoderm in the folding, the two surfaces fuse together and are invaded by mesogloea, which cuts off one canal from another, leaving those endodermal tracts free that have not been in contact. The endoderm in the interior of the greatly strengthened and thickened arm that is thus produced is now confined to the lining of the vertical and lateral channels formed by the folding of the originally membranous structure and its consolidation in the manner indicated. The distal extremities of the lateral canals remain open and form two linear series of mouths, extending, one on each side of the new margin, down the arm and along each of the terminal lobes.

Yet another folding takes place owing to the growth of these lobes. At first

slightly everted, they tend to grow upwards rather than outwards and so to be folded against the outer margin of the undivided part of the arm. Their ectoderm thus comes in contact with the ectoderm of that part. Ectoderm fuses with ectoderm and is invaded by mesogloea, but as the folding is a simple one no new channels are left open. The characteristic arm of the Triptera is thus produced, formed in its distal region of three lamellae meeting in a vertical line and having a ≻-shaped cross-section.

Another point that may be noticed is the large size of the gastric filaments in the young medusa, in which they are actually as large as—relatively of course much larger than—in the adult.

Acromitus rabanchatu is a sluggish medusa usually seen on the surface with its main axis nearly horizontal. Its pulsations are slow and feeble. Probably the fixed stage occurs on rocks or weeds near the south end of the lake, where the young were found in April, July, September and November, but not in January or February. Small copepods were noticed in the stomach of the young. The stinging-cells have little or no effect on the human skin. Personally I could detect none.

The most striking point in what we ascertained as to the biology of this medusa is the effect that an irruption of fresh water has on its habits and physiology. We noticed that medusae were absent from the surface of the northern part of the main area of the Chilka Lake for a considerable part of the year in which they were fairly common in Rambha Bay, although the prevailing wind had a tendency to drive them northwards. The season at which we did not find them on the surface off Barkul and Nalbano was that at which fresh water, which never penetrates fully into Rambha Bay, was prevalent in the northern parts of the lake. At this season our nets often brought up specimens of *Acromitus* from the bottom; they seemed to be unusually sluggish, to have unusually flat disks and long arms; but we did not notice anything very definitely peculiar. By a fortunate chance abnormal meteorological conditions made it possible to make a much more definite observation in the Ennur backwater near Madras in January, 1915. At that time, at a season at which the weather is usually dry, heavy rain had fallen and the specific gravity of the water in the upper reaches of the lagoon had sunk, probably quite suddenly, at least as low as 1·001. No medusae were seen on the surface, but every haul of the bottom-nets brought up specimens; in one case as many as twenty in a haul. At first sight they appeared to be dead; no movement of any kind could be detected and the circular muscles of the disk were uncontracted and flaccid. The disks were so flat, owing partly to the condition of the muscles but mainly to an actual shrinkage of the jelly, that the specimens were recorded provisionally as representing either a distinct species or a phase of *A. rabanchatu* in which the disk retained the post-larval form; the arms, in consequence of the shrinkage of the bell, appeared to be exceptionally long. That the medusae were not dead was proved by two facts—they exhibited no signs of decay and the spots on their umbrellas were clear and well-defined. The latter fact is particularly important, because in medusae of this species

that are allowed to die in water the pigment of the spots begin to "run" immediately, staining the surrounding medium. The Ennur specimens were of all sizes from a diameter of about 3 cm. to about 20 cm.

These facts, taken in conjunction with the observations recorded on *Halianthus limnicola* and *Edwardsia tinctrix* on pp. 91, 95 of this paper, justify an expression of the belief that some individuals of certain coelenterate species, if forced to live temporarily in water of very low specific gravity (*i.e.* greatly decreased salinity), are able to survive in a state of quiescence or torpidity for considerable periods, and that the most obvious direct structural effect of such conditions is a shrinkage of the mesogloea. If unduly prolonged these conditions cause the deaths of many individuals. The more marked results at Ennur, as compared with those noticed in the Chilka Lake, were probably due to the greater suddenness of the change.

In the Chilka Lake, but not at Ennur, a small amphipodous crustacean was almost invariably observed among the tentacles on the mouth-arms of large individuals of *A. rabanchatu* and occasionally also on the subumbrellar surface. It was not present on very young medusae. In the gastric cavity of these latter, among the gastric filaments, ova were frequently observed, giving, together with the large relative size of the filaments, a false appearance of sexual maturity. The ova, however, were not confined to the gastric cavity but occurred scattered throughout the vascular system and in particular in the circular canals; they are shown as white spots in the photographs of young medusae reproduced on plate vi. A microscopic examination revealed no ovarian tissue, and there can be no doubt that the ova were not proper to the medusae. Mr. T. Southwell has been kind enough to examine a series of well-preserved specimens. He agrees with me in thinking that the eggs are not those of the commensal amphipod but probably belong to some helminth parasite. They are in various stages of segmentation and the formation of a blastula, but unfortunately have not reached in any case a higher stage of development and have not as eggs any distinctive structural character. In size and shape, however, they closely resemble eggs found with immature Distomid Trematoda in the canals of a Ctenophore common in the Chilka Lake (p. 118). No eggs of the kind were observed in adult medusae.

The main breeding season of *A. rabanchatu* occurs in the Chilka Lake, to judge from the condition of the gonads in specimens, towards the end of the cold weather, *i.e.* in February and March.

HYDROZOA.

(Plate ix, in part.)

We obtained in the Chilka Lake specimens of eight or nine species of Hydrozoa, representing four orders, seven families and eight or nine genera. The alternative numbers in species and genera are due to doubt as to the association of a medusa

with its hydroid generation. All the orders of the group except the Trachomedusae and the Hydrocorallinae are represented, but the Narcomedusae and the Siphonophora each include only one casual visitor. The true hydroids are better represented; among the Calyptoblastic families, the Campanulinidae have a single medusa (a casual visitor), and the Campanulariidae two hydroids, each belonging to a separate genus, as well as a medusa that may very well be co-specific with one of the hydroids. One Calyptoblastic hydroid is a casual visitor, while another establishes itself in the outer channel, in which a medusa belonging to the same group was also found as a casual visitor, in the salt-water season. The Gymnoblastea are represented by three hydroids, two of which are permanent inhabitants of the main area of the lake, while the third was found only in the outer channel and in the salt-water season.

Most of the casual visitors and periodic immigrants are marine species of wide distribution. Of the four free-swimming forms included in these categories one is cosmopolitan and one Indo-Pacific, one is widely distributed in the Bay of Bengal and the neighbouring seas, while the fourth, though only known as a medusa from the outer channel of the lake, is perhaps the other generation of an Indo-Pacific hydroid found with it. Of the three fixed forms that are not permanent residents two are Indo-Pacific while one was described from Ceylon.

The two permanent residents, on the other hand, are both species that were originally described from the Gangetic delta and are as yet known only as inhabitants of brackish water on the east coast of India.

Order NARCOMEDUSAE.

Family AEGINIDAE.

Genus **Solmundella** Haeckel.

Solmundella bitentaculata (Quoy and Gaimard).

1904. *Solmundella bitentaculata*, Browne, *Faun. Geogr. Maldives and Laccadives* II, p. 741, pl. lvi, fig. 3.

1905. *Solmundella bitentaculata*, *id.*, *Rep. Ceylon Pearl Fish.* IV, p. 153, pl. iv, figs. 1-6.

1910. *Solmundella bitentaculata*, Mayer, *Medusae of the World* II, p. 455, fig. 301 (p. 457).

An excellent figure of this peculiar little medusa as it appears when contracted is given by Browne (1904). In his paper of 1905 he gives further particulars. Mayer regards the *Aeginopsis mediterranea* of Müller as no more than a variety. If this is so, the species occurs in all seas but has become sufficiently differentiated in the Mediterranean to be distinguished there as an endemic race. As Mayer points out, referring to Vanhoffen's report on the Narcomedusae of the 'Valdivia' (*Narcomedusen der 'Valdivia' Exp.*, p. 45), "*Solmundella* is the most widely distributed Narcomedusa known, ranging from the North Atlantic, through the tropical Pacific

and Indian Oceans to the Antarctic. Living at temperatures of 27° to 1° C, and in depths ranging from 1,500 fathoms to the surface."

A single small specimen was taken in a tow-net on the surface of the outer channel of the Chilka Lake near Barhampur Id. on March 14th, 1914. The salinity of the water at the time was practically identical with that of the Bay of Bengal outside the bar. The medusa must be regarded merely as a casual and perhaps involuntary visitor to the lake.

Order SIPHONOPHORA.

Family DIPHYIDAE.

Genus **Diphyes**, Cuvier.

Diphyes bojani (Chun).

1911. *Diphyes bojani*, Bigelow, *Mem. Mus. Zool. Harvard*, XXXVIII, No. 2, p. 251; pl. vii, figs. 2, 3; pl. viii, fig. 6; pl. ix, figs. 1, 2; pl. x, figs. 2, 3; pl. xi, fig. 5; pl. xii, fig. 1.

The synonomy of this species is discussed by Bigelow in the paper cited. Our specimens agree well with the figure of *Diphyes gegenbauri* published by Lens and Van Riemsdijk in their report on the Siphonophora of the 'Siboga' (*Siboga-Exp.* LX, pl. vii, fig. 57), or in some cases with that of *Doromosia pictoides* (*op. cit.*, pl. i, fig. 1). The species is evidently a variable one and the shape of the anterior nectophore depends to some extent on the condition of preservation of specimens.

In our collection from the Chilka Lake I have found anterior nectophores only.

D. bojani is widely distributed in the Indo-Pacific Region. It is not a permanent inhabitant of the lake, but is to be found in considerable numbers in the outer channel in the salt-water season. It was usually present in our tow-nettings obtained there in March, 1914.

Order CALYPTOBLASTEA.

Family CAMPANULINIDAE.

Genus **Campanulina**, van Beneden.

1868. *Campanulina*, Hincks, *Brit. Hydr. Zooph.*, p. 186.

Campanulina ceylonensis (Browne).

1905. *Irene ceylonensis*, Browne, *Rep. Ceylon Pearl Fish.*, p. 140, pl. iii, figs. 9-11.

1905. *Irene palkensis*, *id.*, *ibid.*, p. 141, pl. iii, figs. 12-16.

1907. ,, *ceylonensis*, Annandale, *Journ. As. Soc. Bengal* (n. s.) III, p. 79, pl. ii, fig. 5.

1907. ,, *ceylonensis*, *id.*, *Rec. Ind. Mus.* I, pp. 38, 142, fig. 2.

1910. *Phortis palkensis* + *Ph. ceylonensis*, Mayer, *Medusae of the World*, p. 309.

The position of the medusa of this species is somewhat enigmatical. Browne placed it in *Irene* (or *Eirene*), and Mayer, relying wholly on Browne's description, in *Phortis*. It seems to me to have affinities with *Tima*,[1] but does not altogether agree with that genus, although its gonads, when fully adult, reach practically from the base of the manubrium to the edge of the disk; there are no cirri and no conspicuous band of longitudinal muscles on the lower side of the tentacles. I have, however, been able to detect a very thin band of the kind in this position. As the hydroid is merely a dwarfed *Campanulina*, it seems best to place the species in that genus, in which the adult medusae have not been satisfactorily identified.

The hydroid[2] forms a minute colony barely visible to the naked eye. It consists of a sparsely branching adherent rhizome that gives origin at intervals to single hydrothecae borne on short ringed pedicels about one-seventh as long as the cup. The hydrothecae are nearly cylindrical and can be closed above by an operculum consisting of several triangular flaps. The hydranth has about 14 very long slender tentacles with regular rings of stinging-cells and but slightly webbed at the base. The hypostome, which is conical, is small and inconspicuous.

Medusae from Port Canning in the Gangetic delta exhibited every gradation between Browne's two nominal species (1907 (2), pp. 140, 141). An increase in the number of concretions in the otocysts was regularly correlated with the production of extra tentacle-bulbs that did not reach their full development. Both changes were apparently due to degeneration and took place towards the end of the season at which the medusa flourished (December to March), when the water of the pools in which it was found began to grow hot.

The hydroid was found on the leaves and stems of water-plants at Port Canning in November, December and January. Both medusa and hydroid have now disappeared from the pools.

The medusa is common off the coast of Burma in winter. It was taken in the Gulf of Manaar and Palk Straits in March and July. At Port Canning, the only locality at which the hydroid has been found, both generations flourished for a time in brackish water. Neither was, however, found in the main area of the Chilka Lake and the species is represented in our collection by a single medusa that was taken in the outer channel, in salt water, in March.

In the second of my papers published in 1907 I dealt with the feeding habits of the medusa, which sucks out the contents of filamentous algae as well as swallowing small Gastropod molluscs and finally ejecting their shells. It is the hardiest medusa with which I am acquainted and will survive for some hours corked up, several individuals together, in a small tube carried in the waistcoat pocket.

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[1] For definitions of the different medusoid genera here referred to see Mayer's *Medusae of the World* II, pp. 307, 311, 314.

[2] All my specimens of this hydroid are now in the hands of Dr. Ritchie of the Royal Scottish Museum, who will, I hope, give a full description in his account of the shallow-water hydroids of the Indian Seas. Dr. Ritchie will describe shortly in the *Records of the Indian Museum* a minute and very interesting hydroid from brackish water in the Gangetic delta.

Family CAMPANULARIIDAE.

Genus **Obelia**, Peron and Lesueur.

Obelia spinulosa (Bale).

1888. *Campanularia* (?) *spinulosa*, Bale, *Proc. Linn. Soc. N. S. Wales* (2) III, p. 756, pl. xii, figs. 5-7.
1910. *Campanularia* (?) *spinulosa*, Ritchie, *Rec. Ind. Mus.* V, p. 5.

A single specimen of this species was taken in the main area of the lake in July, 1913. It grew on a piece of drift-weed stranded among rocks near Patsahanipur and though many of the polyps were alive, was in a somewhat degenerate condition. A few gonothecae were present but did not contain gonosomes.

The information that the hydroid is an *Obelia* I owe to Prof. K. Ramunni Menon of Madras, in whose laboratory the medusa has been reared. I have also to thank him for the sketch reproduced (fig. 9), which was made from life by his pupil Mr. A. V. Narayananvami Ayer.

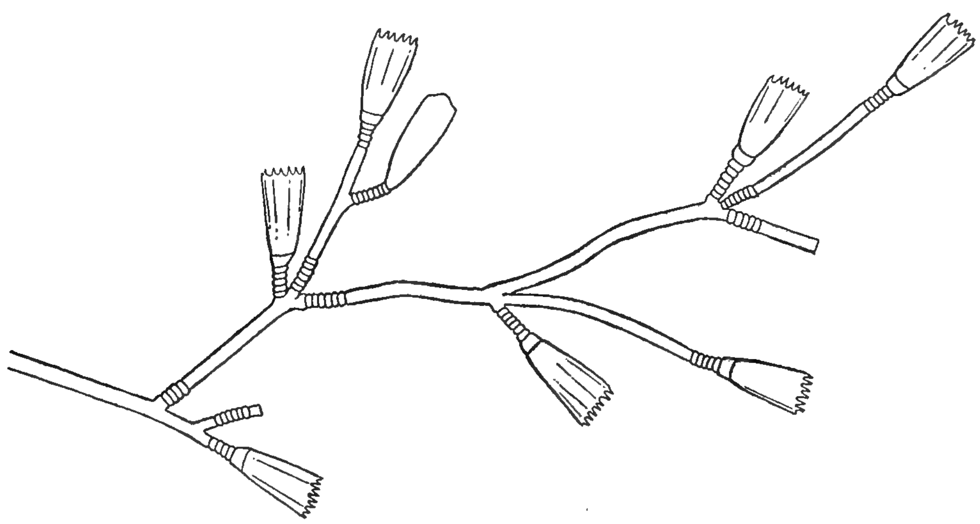

FIG. 9.—*Obelia spinulosa* (Bale).

O. spinulosa was originally described from N. S. Wales and has since been recorded from Java and the Andamans. It is very common (with *Clytia geniculata*, Thornely) in Madras harbour, in which it grows on the shells of mussels, etc.

Genus **Clytia**, Lamouroux (Hincks).

1868. *Clytia*, Hincks, *Brit. Hydr. Zooph.*, p. 140 (Hydroid).
1910. ,, Mayer, *Medusae of the World* II, p. 261 (Medusa).

Clytia serrulata (Bale).

(Plate ix, figs. 1, 1*a*, 1*b*.)

1888. *Campanularia* (?) *serrulata*, Bale, *Proc. Linn. Soc. N. S. Wales* (2) III, p. 257, pl. xii, fig. 4.

So far as can be judged from well-advanced embryos in the gonothecae, this species is a *Clytia*; it is certainly neither a *Campanularia* nor a *Gonothyraea*. The

possibility of its being the hydroid of a *Phialidium* is not, however, excluded, and it may be the vegetative generation of the medusa described below as *Phialidium cruciferum.* Of this there is no direct proof, but the fact that the medusae and hydroid were found together in a fauna so poor as that of the Chilka Lake is at any rate noteworthy.

The hydrothecae and the other purely vegetative parts of the colony agree well with Bale's description and figures. The hydranth is much stouter in structure (pl. ix, fig. 1) than that of *Obelia spinulosa* and has a wider and more trumpet-shaped hypostome. The tentacles are less attenuated. The basal part of the hydrotheca is separated off from the remainder by a delicate membrane.

The gonothecae are mostly produced in groups and arise directly from the anastomosing rhizome. They are placed vertically on very short, obscurely annulated stalks. Sometimes they also arise on the stems, near the base of the stalks of the hydrothecae; in this position their stalks are longer and more distinctly annulated. They are somewhat variable in form, and often distinctly irregular and asymmetrical in outline. Generally speaking, they may be described as being narrowly oval, *ca.* 4 times as long as broad and truncate distally, with a slight constriction near the distal extremity and sometimes another about half way down. They vary in length from 0·68 mm. to 0·85 mm. There are no annuli on the surface.

In the specimens of an *Obelia* from New Britain assigned by Miss Thornely[1] to this species the hydrotheca was evidently much shorter than in Bale's types.

Clytia serrulata was originally described (with *Obelia spinulosa*) from New South Wales. We found a considerable number of specimens at two stations in the outer part of the outer channel of the Chilka Lake in March, 1914, in salt water. The species is probably a periodic immigrant into this part of the lake.

The original Australian specimen was growing on another hydroid (*Tubularia*). Ours were on a fragment of *Pennaria* that had been washed in from the sea, on roots of grass, a dead leaf and dead Lamellibranch shells Many hydranths of those taken at the mouth of the lake contain larval appendicularians in the gastric cavity and these animals would seem to constitute an important element in the food of the species.

Genus **Phialidium,** Leuckart.

1910. *Phialidium*, Mayer, *Medusae of the World* II, p. 265.

Although many medusae of this genus have been described none have been associated with the hydroid in a satisfactory manner. Probably it is identical with *Clytia.*

Phialidium cruciferum, sp. nov.

(Plate ix, figs. 2, *2a*, *2b*.)

As I have pointed out above, this may be the medusa of *Clytia serrulata* (Bale). Our specimens met with an unfortunate accident, owing to which they are all some-

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[1] *Obelia serrulata*, Thornely, "The Hydroid Zoophytes", etc., in Willey's *Zoological Results*, p. 453, pl. xliv, fig. 5.

what distorted. This has made it impossible to obtain a satisfactory profile figure, but the medusa possesses several distinctive characters that can be illustrated in detail even from our material.

In outline the medusa resembles *Ph. globosum* (Mayer)[1] having abundant jelly and an evenly curved bell. The manubrium, gonads and tentacle-bulbs are deep flesh-colour. The bulbs are tinted with brown externally and there is a dark brown cross on the base of the manubrium as seen from the exumbrellar surface. It is composed of four pairs of parallel lines of equal length, one pair on the proximal part of the roof of each radial canal. As a rule the four lines do not quite meet in the centre. Specimens with fully developed gonads are about 6 mm. in diameter.

The number of tentacles is variable and their arrangement irregular. In all the specimens examined a considerable proportion of them are not fully developed and the number of perfected tentacles is often different in different quadrants of the same individual. The radial tentacles are no longer than some of the others. The number, as well as the arrangement, of the otocysts is also variable. Sometimes two are situated close together, but more often several tentacles intervene. They are very small and inconspicuous.

The velum is narrow.

The manubrium is relatively long and has four long deeply-fringed lobes.

The gonads are narrowly spindle-shaped and about equidistant when young from the margin of the bell and from the manubrium. When mature they occupy more than half the length of the radial canals and approach the margin, also becoming more band-like and somewhat contorted.

Type.—No. Z.E.V. 6827/7, *Ind. Mus.*

Distribution.—Taken in large numbers on the surface in the outer channel of the Chilka Lake (Orissa) in salt water, March, 1914.

This species is apparently related to *Ph. iridescens*, Maas,[2] from which it differs in colour, in its much larger manubrial lips, and probably in other characters. *Ph. iridescens* has been found only in the Antarctic Ocean.

Order GYMNOBLASTEA.

Family HYDRACTINIIDAE.

Genus **Clavactinia**, Thornely.

Clavactinia gallensis, Thornely.

1904. *Clavactinia gallensis*, Thornely, *Rep. Ceylon Pearl Fish.* II, p. 111, pl. i, fig. 3.

In sorting out our collection we found on several small shells colonies of a minute Hydractiniid that agrees with Miss Thornely's description sufficiently well. The animal escaped our attention in the field.

[1] *Oceania globosa*, Mayer, *Bull. Mus. Zool. Harvard*, XXXVII, p. 51, pl. x, figs. 20, 20*a* (1900); *Phialidium globosum* (in explanation of plate "*globulosum*"), *id.*, *Medusae of the World* II, p. 272, pl. xxiv, fig. 4.

[2] *Exp. Antarct. 'Belgica', Medusen*, p. 12, pl. i, fig. 6 (1906).

The colonies are evidently young or dwarfed. Only one bears fully developed gonosomes and even in this colony the basal crust is still imperfectly developed and remains at many points openly reticulate. In one colony it is still in the primitive condition of a branching and anastomosing rhizome bearing upright hydranths at intervals. The largest shell to which a colony was attached was only 23 mm. long.

The largest hydranths are not more than 2 mm. long and the majority are much shorter. The number of tentacles is variable, but I have not seen more than 14. Their nematocysts are very small. Even when fully expanded the tips are blunt.

There are no true dactylozooids, but young gonophores were at first sight mistaken for them. These individuals have a large central cavity at the base, which is somewhat inflated. The region on which the gonosomes are borne is elongated and slender. Its tip is blunt and not at all capitulate. In this region the structure forms a solid finger-shaped mass. Brownish granules occur abundantly in its internal cells. Each female gonosome bears three ova. Except in being a little more inflated at the base, the whole gonophore, in mounted specimens rendered transparent, somewhat resembles the larger spines but may be distinguished therefrom, in the absence of gonosomes, by its basal cavity and by the absence of a thickened chitinous external coat. The gonophores are shorter than the largest hydranths.

Clavactinia gallensis was originally taken in Galle Bay on the west coast of Ceylon in two fathoms. Our specimens were found close inshore in not more than two feet of water at Satpara in the outer channel of the Chilka Lake.

The former specimens were attached to shells of *Eburna* and *Neritina*; Miss Thornely does not say whether these shells were inhabited. Ours were in most instances on shells of *Potamides fluviatilis*, and in one on a shell of *Nassa labecula*. In both cases small hermit-crabs (*Diogenes avarus*, Heller) were living in the shells, both species of which are abundant at Satpara. The hydroid was present on a small proportion only of the shells collected, though many had been appropriated by hermit-crabs. Our specimens were taken in March, in water practically as salt as that of the upper part of the Bay of Bengal at the same season. It is probable, in view of the immature condition of most of the colonies in March, that the planulae are brought in by the tide in the season of salt water and that the species does not survive the irruption of fresh water that takes place later in the year.

A minute Campanularian hydroid accompanied *Clavactinia* on one shell, but the specimen was unfortunately too imperfect for even partial identification.

Family CORYNIDAE.

Genus **Dicyclocoryne**, nov.

This genus may be defined as consisting of Corynidae in which the tentacles of the hydranth are all capitate and are disposed in two quite distinct circles. The gonosomes, which are borne on the proximal part of the hydranths, are free medusae and have, when liberated, four short, stout capitate tentacles, one at the end of each radial canal, but no ectodermal ocelli. The manubrium, at the same stage, is short,

conical and apparently imperforate. Nothing is known of the development of the gonads.

Type-species.—Syncoryne filamentata, Annandale.

The genus is at present known only from brackish water on or near the east coast of India.

Dicyclocoryne filamentata (Annandale).

(Plate ix, figs. 4, 4*a*, 4*b*, 4*c*.)

1907. *Syncoryne filamentata*, Annandale, *Rec. Ind. Mus.* I, p. 139, figs. 1, 2.

The colonies of this species often have a peculiarly lax appearance owing to the fact that the rhizome is adherent only in places and is sometimes produced into long filamentous free processes that bear terminal polyps. These, or rather the stalks from which they arise, may again become attached at their base to the object on which the colony is growing, so that loops of free rhizome are formed. The whole colony, except of course the hydranths, has a fairly thick chitinous investment. The rhizome branches sparingly and does not anastomose. Short vertical stems are produced at intervals, but as a rule bear only one (terminal) hydranth. A second (lateral) polyp is, however, sometimes present. The stems and rhizome, including the free portions of the latter, are often irregular in outline without being exactly annulate. Their diameter does not exceed 0·19 mm.

When fully expanded the hydranths are slender and spindle-shaped. They have a well-developed sheath of ectocyst at their base. As a rule there are about four tentacles in the proximal and six in the distal circle, but the number is variable and individual hydranths are occasionally found in which they are aborted and reduced in number. When normally developed they are capable of great extension and even in contraction the cylindrical part of the tentacle is longer than the terminal swelling. The latter is very large, circular and somewhat flattened. The largest hydranths are probably never more than 2·5 mm. long.

The gonosomes are borne at the bases of the proximal ring of tentacles or distinctly below them at the base of the hydranth.

The medusa is about 0·4 mm. in diameter when liberated. Its bell in life is slightly deeper than broad. In profile, the sides, except in extreme contraction, are nearly straight and the upper outline moderately convex. The cross-section is subquadrate. The surface is minutely tuberculate but has no conspicuous projections or specialized organs. The velum is broad. There are no marginal processes of any kind between the tentacles.

The tentacles are incapable of great elongation and in all circumstances remain shorter than the bell. They are somewhat flattened from without inwards and bear on each side a series of minute projections which decrease in size from above downwards. The terminal expansion, which is full of large nematocysts, is circular and somewhat flattened from above downwards. The tentacle-bulbs are relatively large but lack all traces of ocelli. As a rule they contain one or several large nematocysts. Immediately below them there is a broad band of stinging cells; below this band

there is another narrower and less prominent one of the same nature. In the living animal the two bands can hardly be distinguished.

The endodermal parts are colourless. The manubrium is a stout conical body much shorter than the bell. Its walls are very solid and I can detect no orifice. There is, however, a relatively large lumen at the proximal end.

The radial canals are simple and slender.

Types.—Hydroid, No. Z.E.V. 2424/7: Medusa, No. Z.E.V. 2436/7, *Ind. Mus.*

This species is closely allied to those that form the genus *Syncoryne* (Ehrenberg) as restricted by Allman, but the hydranth is distinguished from their hydranths by the arrangement of the tentacles. The medusa is distinguished from *Sarsia*, Lesson, by its capitate tentacles and lack of ocelli.

Distribution.—The hydroid, from which medusae were hatched in Calcutta, was originally found in a small artificial pool of brackish water at Port Canning in the Gangetic delta. In the Chilka Lake we found the hydroid, with developing medusae, on two occasions in the main area, in Rambha Bay and near Pigeon Island, in both cases on the surface.

The type-specimens, which were taken in December, 1907, were growing on a grass-stem in water of low salinity. Our examples from the Chilka Lake are on a leaf of *Halophila ovata* and on the stem of an indeterminate water-plant. They were collected in July, 1913. The salinity of the water was not ascertained at the time, but in July, 1914, the specific gravity in Rambha Bay was about 1·015. The species is evidently scarce in the lake, but is probably a permanent resident in the main area.

Family BOUGAINVILLIIDAE.

Genus **Bimeria**, Wright.

1868. *Garveia+Bimeria*, Hincks, *Brit. Hydr. Zooph.*, pp. 101, 103.
1871. *Garveia+Bimeria*, Allman, *Mon. Gymn. Hydr.*, pp. 249, 297.
1902. *Bimeria*, Torrey, *Zool. Pub. Univ. California* I, p. 20.
1905. *Perigonimus* (in part), Motz-Kossowska, *Arch. Zool. expérim.* (4) III, p. 71.
1905. *Pruvotella, id., ibid.*, p. 77.
1907. *Bimeria*, Browne, *Journ. Mar. Biol. Ass. Plymouth* VIII, p. 19.

Bimeria fluminalis, sp. nov.

(Plate ix, figs. 3, 3*a*.)

1907. *Bimeria vestita*, Annandale (*nec* Wright), *Rec. Ind. Mus.* I, p. 141, fig. 3.

I am acquainted with two phases of this species, a luxuriant bushy form and a dwarfed one consisting of simple pinnate stems arising at intervals from an adherent rhizome.

In the latter phase the stems are never much more than 20 mm. high and may be reduced to stalks less than a millemeter long and bearing only a terminal

hydranth. The bushy masses of the more robust phase may, on the other hand, reach a length of 20 cm. In both phases the stems are single and even when the colony is most luxuriant they never become agglutinated or even intertwined, its luxuriance being due solely to the profuse production of stems from the rhizome and their still more profuse branching in one plane. Even the largest masses are soft and lax, for the stems and branches are not thickened, and it is only when the former are very short that they are at all stiff.

The chitinous investment of the hydrophyton, though not hard, is thick and brown. It extends up the stalks of the hydranths, round the base of the latter and for a short distance up the tentacles, on which, however, it is thin and almost colourless. Consequently the exact point it reaches can be detected with difficulty. When the hydranths are contracted the thin investment of their bases is to some extent invaginated into the thicker and stiffer covering of the stalk (pl. ix, fig. 3).

The hydranths are spindle-shaped and fairly slender when fully extended, their tentacles are capable of great elongation. As a rule the tentacles, which are borne in two alternating circles, are 8 or 10 in number.

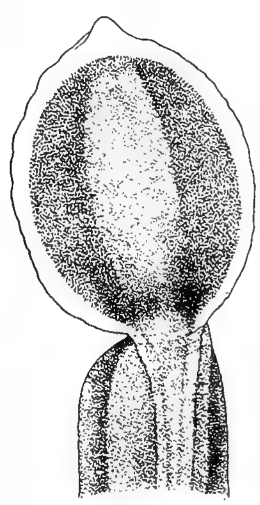

FIG. 10.—*Bimeria fluminalis*, sp. nov. Male gonophore, from a stained specimen.

The base of the stems and lateral branches is always annulated for a short distance, but the annulation is often very obscure. So far as I can see it is never spiral. This is also the case with the stalks of the gonophores, which (the stalks) are always shorter than the gonothecae.

These thecae are borne at the base of the considerably longer stalks of the hydranths. When immature they are almost spherical and when mature vary considerably in size and outline. Generally speaking, those of the female gonophores tend to become cylindrical as the ovum ripens, whereas those of the male gonophores assume an ovoid form with the growth of the gonad and become almost pointed distally. There is usually a small pimple-like projection at the extreme tip, especially in mature male gonothecae (fig. 10).

Traces of the circular canals persist at the base of the gonophores but are not well developed. In both sexes the spadix is a simple cylindrical or somewhat spindle-shaped body. In the female gonophore, which produces a single egg, the spadix extends up one side of the egg and arches over it slightly. The distal extremity is slightly emarginated outwardly, so that the spadix has precisely the shape of the human finger (pl ix, fig. 3*a*). In this sex it is of an orange or brownish colour. The ovum and the young planula are usually white but, at any rate in the bushy form of the species, sometimes have a bluish tinge. The spadix of the male gonophore is symmetrical and somewhat less curved; it extends up the interior of the gonophore nearly to the tip of the latter and is invisible externally in the living animal.

Type.—No. Z.E.V. 6643/7, *Ind. Mus.* The specimen belongs to the bushy phase and was taken in a canal of brackish water on the outskirts of Calcutta.

Bimeria fluminalis is common in both phases in canals, creeks, pools and backwaters of brackish water in the Gangetic delta. In the Chilka Lake the dwarfed form is abundant, especially in the main area, at all seasons.

The species is closely allied to *Bimeria vestita*, Wright, the type of its genus, which occurs in the North Sea and Irish Channel and in the Mediterranean and has been recorded from the Pacific side of South America.[1]

From the British form it differs only, so far as the hydrophyton is concerned, in the more obscure annulation of the stems and the thinner and less conspicuous covering of the base of the hydranth and the tentacles. The cup-like invagination produced at the base of the contracted hydranth is doubtless correlated with the latter feature and is certainly not a generic character. Until I was acquainted with the structure of the gonophore in both sexes I was of the opinion (see *Faun. Brit. Ind., Freshw. Sponges*, etc., p. 140; 1911) that the Indian hydroid was at most a local race of the British one, but the spadix differs in the two, for in the male of *B. vestita* (*fide* Allman) it is branched instead of being simply cylindrical, while in the female,[2] instead of forming a cylindrical process on one side of the ovum, it forms a symmetrical cup in which the ovum rests.

B. fluminalis plays much the same part in the aquatic fauna of the Gangetic delta as *Cordylophora lacustris* does in that of the estuarine tracts at the mouths of the Thames and the Mersey. It reaches its maximum development on submerged timber and there provides a support or a refuge to numerous fixed and free Protozoa, while the Indian race or species (*bengalensis*) of the Polyzoon *Victorella* grows on its branches just as *V. pavida* does on those of *Cordylophora* in England. In the Chilka Lake the dwarfed form of the hydroid is found on rocks and stones and on the stems of water-plants, avoiding only those spots reached by direct sunshine. On stones it is confined to the lower surface, but on rocks it often covers vertical faces. In the Gangetic delta, where there are no stones, this form is usually found on hard artificial objects such as bricks and potsherds but also grows on water-plants in pools. I have never seen the species in places where the water was permanently fresh, but it flourishes in a medium of very slight salinity and can exist for a considerable period in fresh water. The positions it affects in the Chilka Lake are for the most part the same as those affected by *Laxosuberites lacustris*, except that, when the lake is full, it grows higher up the rocks than the sponge. The rhizome is very often completely buried in the sponge, through which the branches protrude. In these circumstances the hydroid is more completely dwarfed as a general rule than it is when growing free; often the hydranths die and the branches disintegrate, leaving only the rhizome, which retains its vitality and doubtless produces new stems if anything happens to the sponge.

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[1] Hartlaub, *Zool. Jahrb.*, Suppl. VI, p. 534 (1905).

[2] I can find no published description of the female gonophore of *B. vestita.* My statement is based on a specimen from Port Erin that Mr. F. H. Gravely has kindly lent me.

The maximum vegetative growth of the hydrophyton, which in favourable conditions must be rapid, takes place in the lake in the salt-water season, but gonophores are produced in the greatest numbers at the time when the lake is inundated with fresh water. Indeed, the most favourable conditions for their production seem to be those most unfavourable for the survival of the hydranths. In the northern part of the main area in September, when the water was quite fresh, we found both male and female colonies covered with gonophores on stems of drift-weed that had been carried by the wind into corners among rocks and had begun to decay. Most of the hydranths had perished, but most of the gonads were developing normally, though a few were degenerate, especially in the male colonies—a circumstance that occurs even in conditions that seem to be more normal. In active colonies growing in water of moderate salinity gonophores were never found in profusion so great, but many are present on the type-specimens, which were taken in water of a specific gravity of 1 006. In these they are almost entirely confined to those parts in which the organism is congested by its own luxuriant growth. They are accompanied by few hydranths, though the younger and freer parts of the colonies were evidently in full nutritive vigour and well supplied with active polyps. It is thus clear that in *Bimeria fluminalis*, as in many other species, sexual reproduction is stimulated by changes in environment that ultimately prove fatal to the colony.

EXPLANATION OF PLATE VI.

ACTINIARIA AND MEDUSAE.

Fig. 1.—*Pelocoetes exul* (Annandale).

Specimens from the Chilka Lake, nat. size.

Fig. 2.—*Halianthus limnicola*, sp. nov.

Type-specimens, enlarged.

Fig. 3.—*Edwardsia tinctrix*, sp. nov.

Type-specimens, enlarged.

Figs. 4-6.—*Acromitus rabanchatu*, sp. nov.

4.—Half-grown specimen divided longitudinally (nat. size).
5.—Young specimen in Semostoman stage, much enlarged.
5*a*.—Same specimen as seen from above.
6.—Slightly older specimen seen from below.

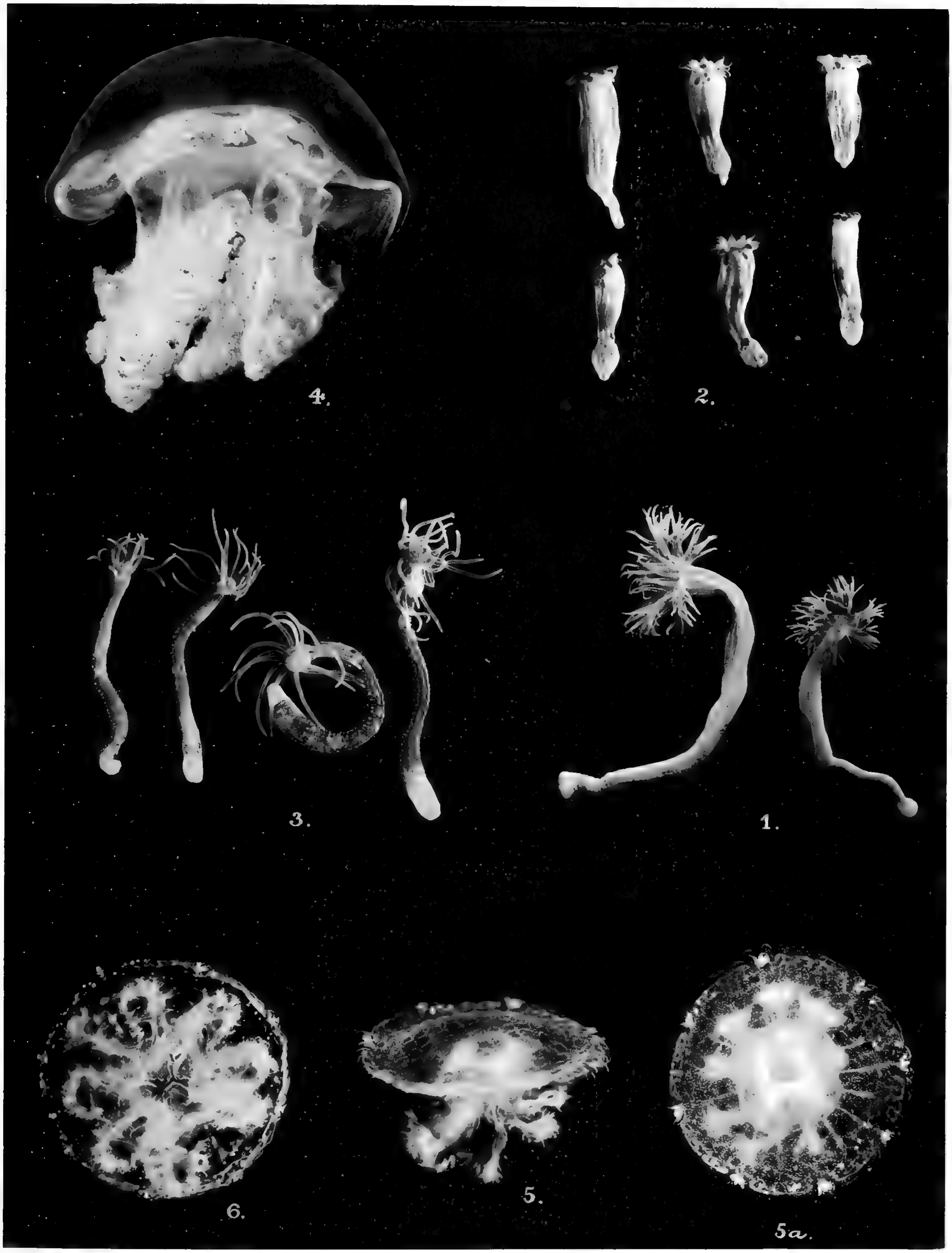


Photo. by S. C. Mondul. Bemrose, Collo., Derby.

COELENTERATES OF THE CHILKA LAKE.

EXPLANATION OF PLATE VII.

Actiniaria.

Fig. 1.—*Metridium schillerianum* (Stoliczka).

Solid transverse section through the lower part of the column.

The sulcus and sulculus are shown at the ends of the longer axis of the stomodaeum.

Fig. 2.—*Phytocoetes chilkaeus*, sp. nov.

Vertical section of the body-wall in the region of the sphincter, × 75.

Figs. 3, 3a, 3b.—*Pelocoetes exul* (Annandale).

3.—A living anemone in a contracted state (nat. size), showing the loose columnar sheath.

The figure is from a sketch made *ad nat.* by Mr. G. M. Henry.

3*a*.—Transverse section of a part of the body-wall in the lower region of the column, × 100.

3*b*.—Vertical section of the body-wall of a small portion of the muscular (upper) region of the column, × 250.

Figs. 4, 4a, 4b.—*Halianthus limnicola*, sp. nov.

4.—Vertical section of the body-wall in the region of the sphincter (highly magnified).

4*a*.—Transverse section of a mesentery passing through the trilobed region of the filament (highly magnified).

4*b*.—Transverse section through a male gonad (highly magnified).

Figs. 5, 5a.—*Edwardsia tinctrix*, sp. nov.

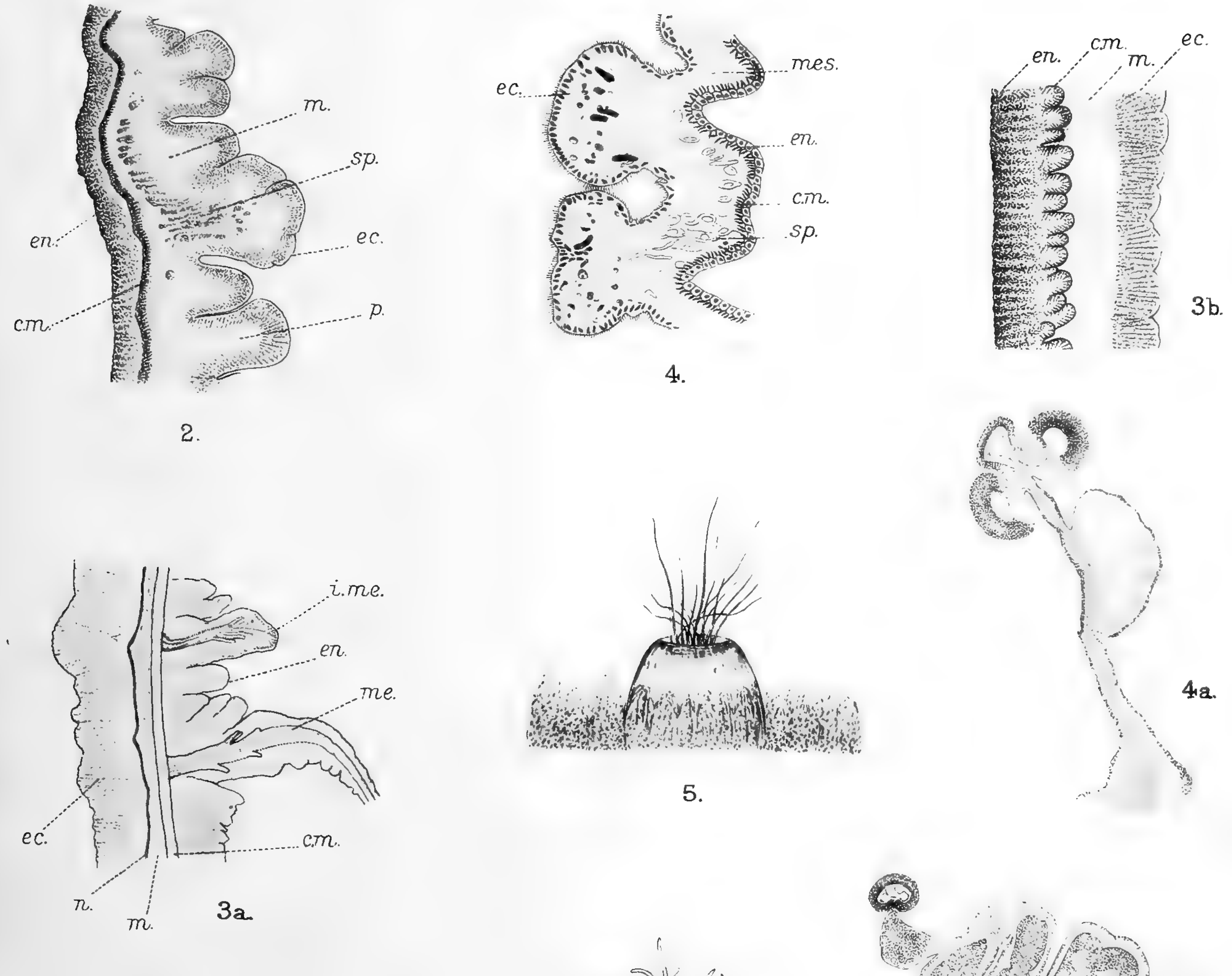
5.—A papilla on the column as seen in profile in a specimen mounted in Canada balsam, showing the nematocysts discharging their threads, × 250.

5*a*.—Transverse section of a papilla passing a little to one side of the centre of the lumen, × 250.

Figs. 1, 2, 3*a*, 3*b*, 4, 4*a*, 4*b*, and 5 are taken from specimens in which the column-wall was in a state of high contraction.

Lettering.

c.m.=circular muscle: ec.=ectoderm: en.=endoderm: i.me.=incomplete mesentery: m.=mesogloea: me.=complete mesentery: n.=nervous layer: p.=cavity of papilla: sc.=remains of nematocyst: sp.=sphincter.



D. Bagchi & A. Chowdhary, del.

Bemrose, Collo., Derby.

ACTINIARIA OF THE CHILKA LAKE.

EXPLANATION OF PLATE VII*a*.

ACTINIARIA.

Fig. 1.—*Gyrostoma glaucum*, sp. nov.

A specimen from the main area of the Chilka Lake, × 2.

Fig 2.—*Metridium schillerianum* (Stoliczka).

Thick vertical section through one half of the column of a specimen with fully expanded tentacles (enlarged); mounted unstained in Canada balsam.

The section passes through an intermesenterial chamber. The dark mass in the chamber is a much contorted acontium.

Figs. 3, 3a, 3b.—*Phytocoetes gangeticus*, sp. nov.

3.—Type-specimens of the species preserved in formalin, × 2.

3*a*.—A living specimen attached to the root of a reed and half buried in mud; the tentacles retracted, × 2.

In this figure the cinclides appear as small white spots on the upper part of the column.

3*b*.—A young specimen stained with borax-carmine and mounted in Canada balsam, × *ca.* 5.

Fig. 4.—*Phytocoetes chilkaeus*, sp. nov.

Type-specimens from the main area of the Chilka Lake, × *ca.* 2.

Fig. 5—*Edwardsia tinctrix*, sp. nov.

Transverse section (somewhat oblique) through the lower extremity of the stomodaeum, highly magnified.

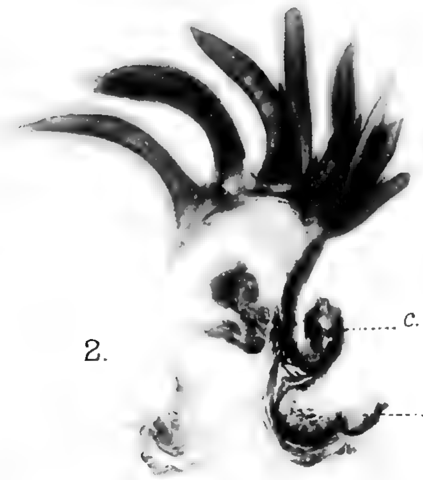
All the figures in this plate are from direct photographs of specimens or preparations.

LETTERING.

b. = basal disk: c. = fold of body-wall that appears when the tentacles are extruded: sp. = sphincter: st. = lower extremity of stomodaeum.

3b.

5.



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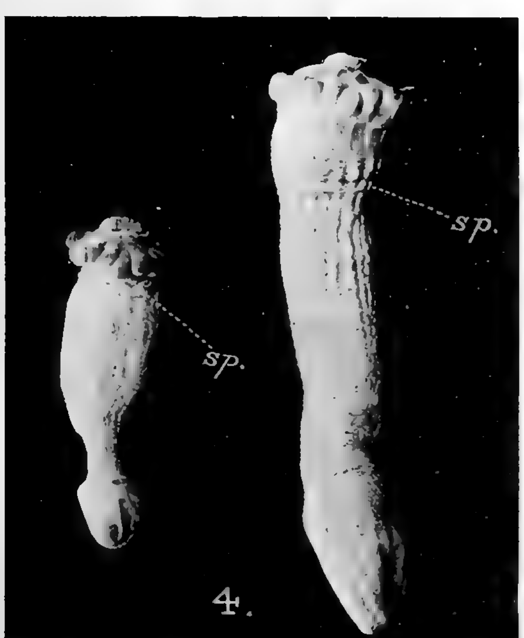
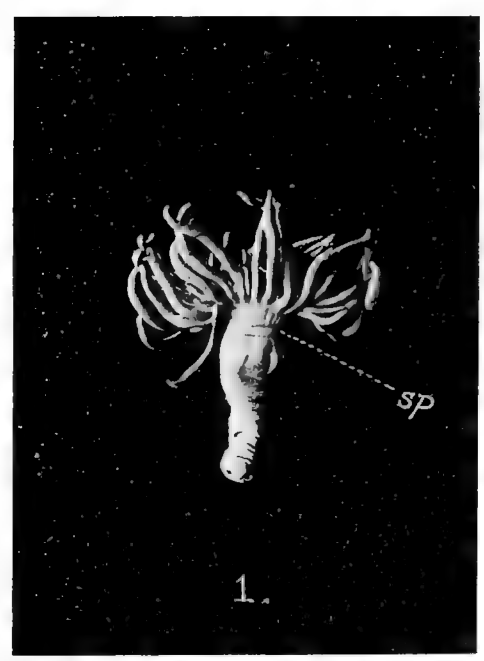


4.

3a.



1.

Photo. by S. C. Mondul. Bemrose. Collo., Derby.

ACTINIARIA OF THE CHILKA LAKE.

EXPLANATION OF PLATE VIII.

SCYPHOMEDUSAE.

Acromitus rabanchatu, sp. nov.

FIG. 1.—Adult specimen (reduced).

The specimen has been preserved in formalin for some time and the bell was therefore flatter than in life.

FIG. 1*a*.—Plan of the disk of the same specimen seen from below on the removal of the arms.

One octant (**X**) of the margin has been removed.

,, 1*b*.—A single arm seen in profile.

,, 1*c*.—The tip of an arm (enlarged) seen from in front.

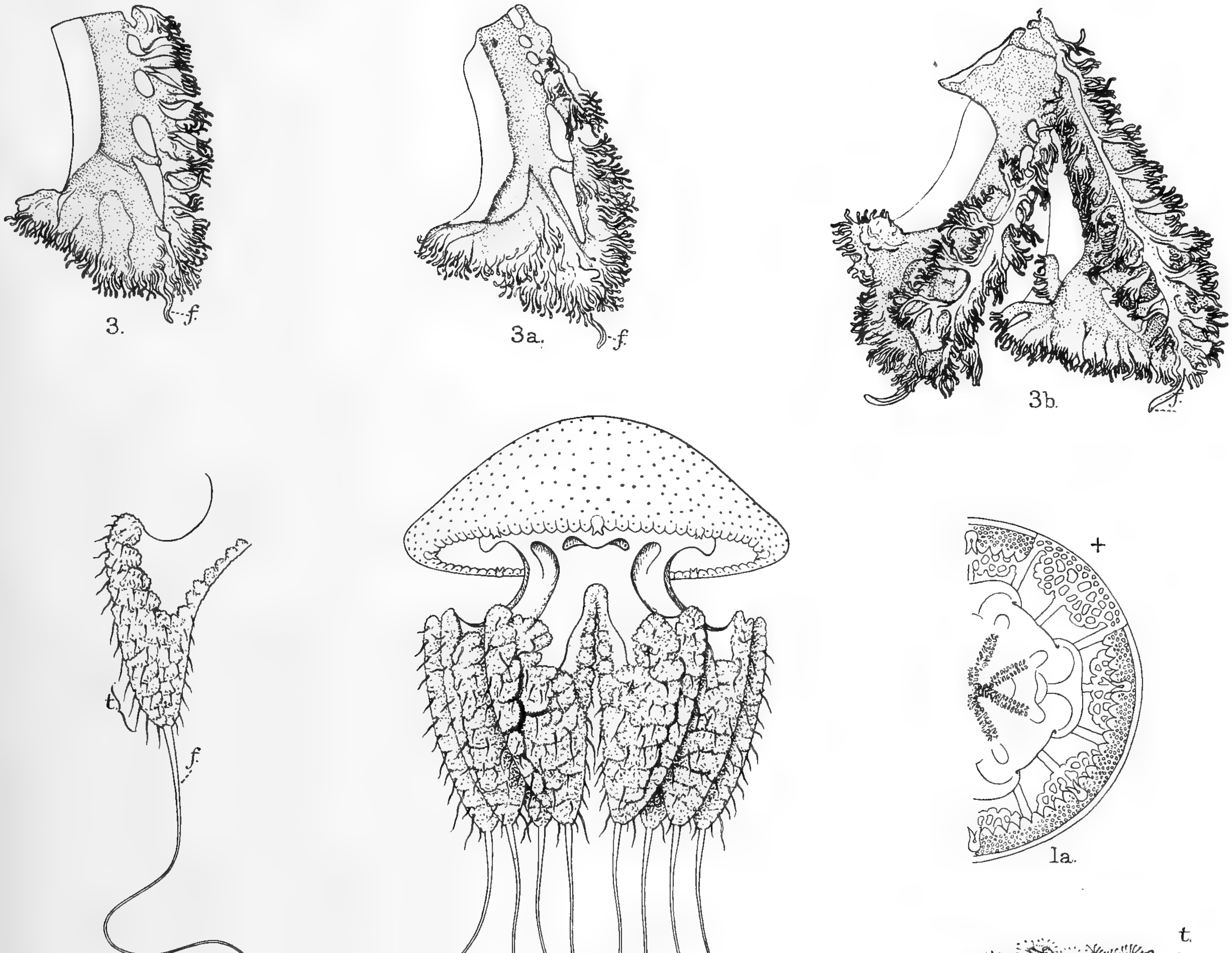
,, 1*d*.—Sense organ as seen from above (greatly enlarged).

,, 2.—Arms of a very young medusa in the Semostoman stage as seen from below (much enlarged).

FIGS. 3, 3*a*, 3*b*.—Arms of a young medusa at a somewhat later stage of development.

LETTERING.

f.=terminal filament of arms: t.=short lateral filaments.



S. C. Mondul & A. Chowdhary, del.

Bemrose, Collo., Derby.

SCYPHOMEDUSAE OF THE CHILKA LAKE.

EXPLANATION OF PLATE IX.

HYDROZOA AND CTENOPHORA.

Figs. 1, 1a, 1b.—*Clytia serrulata* (Bale).

1.—Hydrothecae and hydranth (much enlarged).
1*a*, 1*b*.—Gonothecae from the same specimen (same magnification).

Figs. 2, 2a, 2b.—*Phialidium cruciferum*, sp. nov.

2.—Type specimen of medusa as seen from below (much enlarged).
2*a*.—Part of the margin of the bell in a slightly younger medusa (further enlarged).
2*b*.—Dorsal surface of stomach of the type specimen with proximal part of radial canals (same magnification as in fig. 1).

Figs. 3, 3a.—*Bimeria fluminalis*, sp. nov.

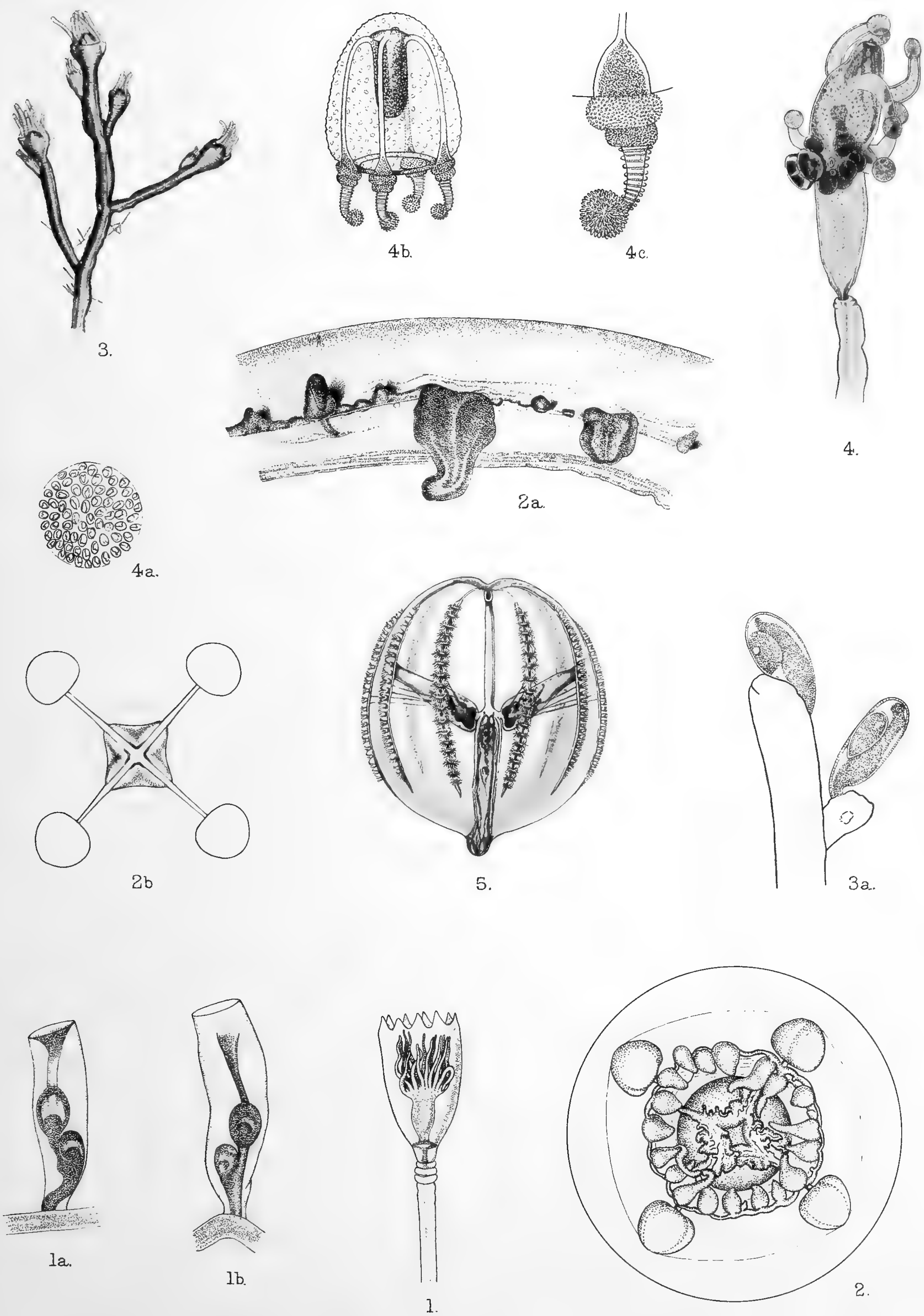
3.—Terminal part of a colony from the Chilka Lake (enlarged).
3*a*.—Female gonosomes from a living specimen from near Calcutta examined under pressure (at a slightly greater magnification).

Figs. 4, 4a, 4b, 4c.—*Dicyclocoryne filamentata* (Annandale).

4.—Hydranth bearing gonosomes (much enlarged).
4*a*.—Terminal part of a tentacle of the same hydranth (further enlarged) as seen from in front.
4*b*.—Young medusa (much enlarged).
4*c*.—A tentacle of the same specimen seen from the inner surface (further enlarged).

Fig. 5.—*Pleurobrachia globosa*, Moser var. *bengalensis*, nov.

Lateral view of a specimen preserved in formalin (enlarged).



A.C. Chowdhary, del.

Bemrose, Collo., Derby.

HYDROZOA & CTENOPHORA OF THE CHILKA LAKE.

FAUNA OF THE CHILKA LAKE

CTENOPHORA.

By N. ANNANDALE, *D.Sc.*, *and* STANLEY KEMP, *B.A.*

(Plate IX, fig. 5.)

CTENOPHORA.

By N. ANNANDALE *and* STANLEY KEMP.

The only member of this group represented in our collection is a representative of the order Cydippidea and of the genus *Pleurobrachia*, Flemming, forming a race of *P. globosa*, Moser, a species originally described from the Malay Archipelago. For this race we propose the name *bengalensis*, as it occurs on at least one side of the Bay of Bengal and differs from the form found in the Gulf of Manaar to which Browne[1] has given the name *ceylonensis*.

Pleurobrachia globosa bengalensis must be classed as a periodic visitor to the Chilka Lake, over the whole of which it is found for a great part of the year. In the fresh-water season, however, it disappears, and does not re-appear until the water has regained a certain salinity. From observations made in the Ennur backwater, near Madras, in January, 1915 it would seem that it is able to live in a medium of sp. gr. 1·0045, but not in one of 1·0025.

In the outer channel of the lake, in the salt-water season of 1914, we captured in our tow-nets on several occasions a species of the order Lobata but the animal was so fragile that we failed to preserve specimens. In formalin it seemed literally to melt away and all attempts at narcotizing it had the same effect.

Pleurobrachia globosa, Moser.

1903. *Pleurobrachia globosa*, Moser, *Siboga-Exp.*, XII (Ctenophora), p. 7, pl. i, figs. 1-4.

The typical form of this species has not been found in the Indian Ocean. We have already alluded to the race endemic in the Gulf of Manaar.

Race **bengalensis**, nov.

(Plate ix, fig. 5.)

In all the more important structural features (*viz.* the relative position of the tentacle-sheaths, of the tentacle-openings, the canals and the stomodaeum and the proportions of the tentacle-sheaths) this race agrees with the typical form of the species, from which it differs in all the points noted by Browne in his description of his variety *ceylonensis*. From that form, however, it differs in that in the vast majority of individuals, the costae are still longer, being about twice as long as in the typical form and at least a quarter longer than in *ceylonensis*. The length of the meridional canals, which extend for the whole length of the costae, is also relatively longer than in the latter, but the opening into them of the adradial canals is also

[1] Herdman's *Ceylon Pearl Fisheries* IV, p. 161 (1905).

median. In most individuals each costa consists of about 28 ciliated plates, which diminish gradually in size towards both extremities. Neither the number of plates nor the exact proportions of the costae are quite constant and individuals occur in which one or more of the costae are shorter than the others; in one individual examined the number of plates varies from 16 to 23. In all our specimens the tentacle-base is pressed more or less closely against the stomodaeum and is, perhaps for this reason, concave, but in the living animal its precise relative position, like the precise outline of the whole organism, is liable to almost constant change. The tentacles are capable of great elongation; processes are absent from a considerable part of the distal half, but are uniformly developed on the remainder of each tentacle; to judge from specimens in which they are contorted, they are cylindrical and capable of being coiled in a close spiral with many whorls. In life the tentacles are yellow and the remainder of the animal colourless.

The longer axis never exceeds 1 cm. in length.

We have examined specimens of this form from the coast of Orissa and from the Ennur backwater near Madras, as well as from all parts of the Chilka Lake. The animal swims as a rule from 2 to 4 feet beneath the surface.

In many of our specimens taken in July the jelly, more particularly in the neighbourhood of the stomodaeum, funnels and tentacle-sheaths, contains a large number of minute and apparently immature Distomid trematodes. They are accompanied by eggs, hardly smaller than themselves, resembling those found in the canals of the young of *Acromitus rabanchatu* (p. 102, *antea*). On the external surface of a few individuals we found Protozoa of the genus *Trichodina*.

The type-specimens of the race are numbered Z.E.V. 5936/7 in the books of the Indian Museum.

FAUNA OF THE CHILKA LAKE

THE POLYZOA OF THE LAKE AND OF BRACKISH WATER IN THE GANGETIC DELTA.

By N. Annandale, *D.Sc., F.A.S.B.*

(With 3 text-figures.)

CONTENTS.

POLYZOA.

By N. ANNANDALE.

Eight species of Polyzoa have been found in brackish water on the coasts of India, but of these only three occur, so far as we know, in the Chilka Lake. A fourth was abundant some years ago in small pools of brackish water near its inner shore, but has now disappeared and has not been taken in the lake itself.

A list of the eight species will be found in the Table of Contents on the opposite page. One half of these species are apparently endemic in estuarine tracts, maritime swamps and lagoons in India, while the other half are cosmopolitan or at any rate very widely distributed. The two series may be tabulated thus:—

ENDEMIC INDIAN SPECIES.	WIDELY DISTRIBUTED SPECIES.
Membranipora bengalensis,	*Membranipora hippopus*,
Victorella bengalensis,	*Bowerbankia caudata*,
Loxosomatoides colonialis,	*Alcyonidium mytili*,
Loxosomatoides laevis.	*Barentsia discreta*.

With one exception the genera are cosmopolitan. The exception is *Loxosomatoides*, which is only known from estuarine tracts and lagoons on the east coast of India. The two species of this genus, as well as the two other endemic forms in the list, have been found only in water of slight or variable salinity, while all the cosmopolitan species are known to occur in the sea. *Loxosomatoides* is closely related to the North American freshwater genus *Urnatella*.

The species found in the Chilka Lake are *Loxosomatoides laevis*, *Membranipora hippopus* and *Alcyonidium mytili*, while the one that formerly occurred in pools in the vicinity was *Bowerbankia caudata*. The first three of these are abundant or at least fairly common in both divisions of the lake, among the permanent inhabitants of which they must all be included. *L. laevis* also occurs in lagoons near Madras and is closely related to the Gangetic *L. colonialis*. The absence of *Victorella* and of *M. bengalensis* is rather strange, for both forms occur almost certainly at Bombay, while the Ctenostome has also been found at Madras. Both are very abundant where they do occur, and neither could well escape the notice of a collector accustomed to look for it. Possibly their absence is due to lack of suitable food.

The only important biological fact I have to add to our knowledge of these brackish-water Polyzoa is that *Loxosomatoides* produces resting buds. The structure of these buds is discussed on p. 130.

In addition to the indigenous Polyzoa of the lake we found within its boundaries specimens of two other species a marine Cheilostome and a freshwater Phylactolae-

matous form. As the presence of both in the region to be considered was evidently adventitious, they may be dismissed here in a few words.

The marine species was *Membranipora tuberculata*, Bosc, a form common in the Atlantic and already recorded from Indian seas by Miss Thornely[1]. A number of young colonies were observed on a stick that had been washed in at the sea-mouth opposite Arakhuda. The species lives attached to floating objects, especially algae[2]; Miss Thornely's specimens, though taken over deep water, were on a floating *Fucus* and evidently came from near the surface.

The Phylactolaematous form I recently described under the name *Plumatella punctata* var. *longigemmis*[3]. It grows luxuriantly in a pond of practically fresh water on Barkuda Island, and in September we found its statoblasts in large numbers on the surface of the main area, on to which they had probably been blown by the wind. We could obtain no evidence that they germinated in the lake and the species can hardly be included in the fauna thereof.

GEOGRAPHICAL LIST OF CHILKA SPECIES.

m.a.=main area: o.ch.=outer channel: sp. gr.=specific gravity of water in the lake.

	CHILKA LAKE.		FURTHER DISTRIBUTION.	sp. gr.
	m.a.	*o.ch.*		
ECTOPROCTA.				
Cheilostomata.				
Membranipora hippopus ..	x	x	Cosmopolitan (*marine and estuarine*).	1·000—1·0275
Ctenostomata.				
Bowerbankia caudata * ..			European seas.	—
Alcyonidium mytili ..	x	x	Cosmopolitan (*marine*).	1·006—1·0275
ENTOPROCTA.				
Loxosomatoides laevis ..	x	x	Madras backwaters (*brackish water*).	1·000—1·0275

* Occurred formerly in pools near shore of main area, not found in lake.

ECTOPROCTA.

CHEILOSTOMATA.

Genus **MEMBRANIPORA**, De Blainville.

1909. *Membranipora*, Levinsen, *Morph. Syst. Studies Cheilost. Polyzoa*, p. 144 (Copenhagen).

Both the species of Cheilostomata to be discussed belong to the genus *Membranipora* as restricted by Levinsen, having the armature of the lateral wall

[1] *Rec. Ind. Mus.* I, p. 185, fig. 3 (1909).

[2] Norman, *Journ. Linn. Soc. (Zool.)* XXX, p. 287 (1909),

[3] *Rec. Ind. Mus.* XI, pp. 168, 169, fig. 2 (p. 166), pl. iii, fig. 2 (1915).

of the zooecium completely covered by a membranous upper or dorsal wall. They are readily distinguished by the following characters:—

M. bengalensis forms a slightly foliaceous colony with a faint silvery lustre and is by no means hyaline. The lip of the zooecium bears a pair of very long and slender bifid spines.

M. hippopus forms an entirely flat colony that is transparent and hyaline; unless the polypides are gorged with food or forming brown bodies, all that is usually visible to the naked eye is a delicate network produced by the armature of the lateral walls of the zooecia; the lip bears no spines.

Membranipora bengalensis, Stoliczka.

1869. *Membranipora bengalensis*, Stoliczka, *Journ. As. Soc. Bengal* XXXVIII (2), p. 55, pl. xii.

1907. *Membranipora bengalensis*, Thornely, *Rec. Ind. Mus.* I, p. 186, fig. 4.

1911. *Membranipora bengalensis*, Annandale, *Faun. Brit. Ind., Freshw. Sponges*, etc., p. 175, fig. 33.

This species has not been found in the Chilka Lake, but is abundant in pools of brackish water in the Gangetic delta, within the limits of which it also occurs in the Salt Lakes near Calcutta. It has also been taken in creeks near Bombay, but Miss Thornely's record from Mergui is due to the misreading of an almost illegible label.

Membranipora hippopus, Levinsen.

1854. *Membranipora lacroixii*, Busk, *B. M. Cat. Polyzoa* II, p. 60, pl. lxix, pl. civ, fig. 1.

1880. *Membranipora lacroixii*, Hincks, *Brit. Marine Polyzoa*, p. 129, pl. xvii, figs. 5-8.

1909. *Membranipora hippopus*, Levinsen, *Morph. Syst. Studies Cheilost. Polyzoa*, pp. 144, 146.

1911. *Membranipora lacroixii*, Annandale, *Faun. Brit. Ind., Freshw. Sponges*, etc., pp. 23, 175.

There has been considerable confusion about this species, but Levinsen has given good cause for considering it distinct from the one described by Audouin as *Flustra lacroixii*.

The armature of the lateral wall of the zooecium is very slight, consisting of two parallel calcified bands of no great depth, one situated at the base of the wall and the other superficial. The area between them remains membranous. Both margins may be either smooth, irregular or minutely denticulate; when denticulate they have a beaded appearance. In the numerous specimens I have examined I have failed to find a single ovicell, but in one a "tower-cell" was present. The small triangular abortive zooecia figured by Hincks (*op. cit.*, pl. xxii, fig. 6) occur rarely in Indian examples. The polypides have 12 very long and delicate tentacles.

The animal is extremely shy and in captivity never extends its tentacles for more than a few minutes at a time. If a healthy colony be observed in favourable conditions the different individuals will be seen to protrude and retract the lophophore frequently, but not either rhythmically or in unison.

Larvae of the Cyphonautes type were taken in our tow-nets at Rambha in January, but were very minute and did not provide any definite specific characters.

M. hippopus is in the broadest sense a cosmopolitan species and seems to be equally at home in brackish and in salt water. It has been found in the Cochin backwaters and in the estuaries of the Ganges, in pools of brackish water, in lagoons and on the open coast of Orissa; off the British coasts it occurs both in brackish ditches, in the littoral zone and in deep water. It is abundant all over the Chilka Lake and flourishes at all seasons, in fresh, brackish and salt water; on the leaves of *Halophila*, the stems of *Potamogeton*, on reeds, on rocks and stones, on the shells (living and dead) of *Purpura* and in the deserted burrows of *Teredo* in a wooden post. On rocks it is frequently overwhelmed by the rapid growth of sponges, but often succeeds for a period in preserving for itself a bare space in the midst of *Laxosuberites lacustris*, which is a very thin encrusting form.

CTENOSTOMATA.

Division *PALUDICELLINA*.

Family VICTORELLIDAE.

Genus **VICTORELLA**, Kent.

1911. *Victorella*, Annandale, *Faun. Brit. Ind., Freshw. Sponges*, etc., p. 194.
1911. *Victorella, id., Rec. Ind. Mus.* VI, p. 195.

It is perhaps best, as suggested in my volume in the *Fauna of British India*, to regard this genus as representing a family distinguished from the Paludicellidae by the fact that there is only a single funiculus which is not connected with the gonads. Braem[1] has recently shown that in *Paludicella* (as well as in *Victorella* and occasionally in *Pottsiella*) secondary buds may be produced in addition to the three primary ones characteristic of the division, and *Pottsiella*, though it resembles *Victorella* in external characters, agrees with *Paludicella* in internal anatomy. The separation of the two families must, therefore, depend on the structure and position of the gonads and funicular strands, and the Victorellidae must for the present be accepted as generically monotypic.

As I have pointed out in the paper cited (1911), the so-called species of *Victorella* are very closely allied and should perhaps be regarded as local races, varieties or phases of a single species. The form common in the Gangetic delta appears to be indistinguishable from one described from Central Asia and is also very doubtfully distinct from an African form found in Tanganyika and in the Egyptian salt lake Birket-el-Qurun.

[1] *Archiv f. Hydrobiol. und Planktonkunde* IX, 1913-14. Unfortunately the copy of this paper in my possession has been mislaid, and I am unable to refer to the page.

Victorella bengalensis, Annandale.

1907. ? *Victorella symbiotica*, Rousselet, *Proc. Zool. Soc. London* I, p. 255, pl. xv, figs. 7-8.

1908. *Victorella bengalensis*, Annandale, *Rec. Ind. Mus.* II, p. 12, fig. 1.

1911. *Victorella continentalis*, Braem, *Trav. Soc. Nat. St. Pétersb.* XLII, p. 30, figs. 18-21.

1911. *Victorella bengalensis*, Annandale, *Faun. Brit. Ind., Freshw. Sponges*, etc., pp. 191-198, fig. 37.

1911. *Victorella bengalensis*, *id.*, *Rec. Ind. Mus.* VI, p. 197, pl. xii, figs. 3, 7, 8.

I cannot find any definite difference between this species and the form from Issyk-kul in Central Asia described by Braem as *Victorella continentalis*. The latter, however, seems to have been founded on young colonies just developing from resting buds. The features in which *V. bengalensis* differs from Rousselet's *V. symbiotica* are also of problematical value, perhaps depending rather on the direct influence of environment than on anything inherent in the organism. In *V. bengalensis*, to use the name provisionally, this influence is powerful in determining the method of growth, and four distinct phases may be noted. First, there are young colonies developing from resting buds on objects the surface of which provides abundance of space. In these the zooecia are short and almost entirely recumbent, closely resembling those of *Paludicella* in shape. Older colonies vary in accordance with the nature of the object to which they are attached. The phase most commonly found resembles a thick fur in which the hairs are represented by upright zooecia, and grows on the stems and roots of grasses and water-plants and occasionally on the shells of Gastropod molluscs. When the colony, attached to supports of the kind, is being overwhelmed by mud owing to the deposition of silt in tidal creeks, the stolons of the secondary buds become greatly elongated and by their entanglement produce a spongy mass; the individual zooecia in this phase of the species are almost entirely vertical and often of considerable height. The simplest adult phase is that found on the stems of the hydroid *Bimeria fluminalis*. In it the colony is much more diffuse than in the two others, and the zooecia, though mainly upright, are more definitely swollen at the base. This phase often approaches very close to the European *V. pavida*, which is commonly found on the stems of *Cordylophora lacustris*, a hydroid that resembles *B. fluminalis* in ecology and manner of growth.

I was surprised not to find this Polyzoon in the Chilka Lake; it is common in the tidal area of the Gangetic delta and has been taken at Madras and also probably at Bombay. In the Gangetic delta it usually affects brackish water, but has been observed with *Plumatella* in a pond of fresh water near a tidal canal. At Madras it was found on the carapace of a freshwater prawn. The food is perhaps restricted to diatoms of a kind that were not observed in the lake, but on this point further information is desirable.

Division *VESICULARINA*.

Family VESICULARIDAE.

Genus BOWERBANKIA, Fane.

Bowerbankia caudata, Hincks.

1880. *Bowerbankia caudata*, Hincks, *Brit. Marine Polyzoa*, p. 521, pl. lxxv, figs. 7-8.

1880. *Bowerbankia gracillima*, *id.*, *ibid.*, p. 525, pl. lxxv, fig. 6.

1907. *Bowerbankia caudata*, Thornely, *Rec. Ind. Mus.* I, p. 196.

1908. *Bowerbankia caudata* race *bengalensis*, Annandale, *Rec. Ind. Mus.* II, p. 13.

1911. *Bowerbankia caudata* subsp. *bengalensis*, *id.*, *Faun. Brit. Ind.*, *Freshw. Sponges*, etc., p. 189.

In the form I have named *bengalensis* the zooecia show every gradation between those of *B. caudata* and those of *B. gracillima* as figured by Hincks, and sometimes even surpass the latter in their elongation and relative slenderness. They also vary in colour, sometimes being quite hyaline and sometimes having a rather opaque brownish tinge. Generally speaking, the zooecia of young or poorly developed colonies and of the younger parts of more luxuriant ones are short, relatively stout, colourless and transparent, while those of more opulent colonies are longer and relatively more slender; it is only some zooecia that become darkened. I have found none in which the "tails" formed branching radicles, but occasionally they are forked. The racial name *bengalensis* can hardly be maintained in view of the variability of the form to which it was applied.

Waters[1] has pointed out that at present it is hardly possible to identify some of the supposed species of *Bowerbankia* and that the "tailed" condition of the zooecia is by no means confined to Hincks's *caudata*. The Indian form, however, is constant in its method of growth, except in so far as it is indicated above, and never produces upright or hanging branches. The gizzard (*i.e.* the part bearing horny teeth) is about 0·058 mm. in transverse diameter when expanded, the length in this condition being considerably less than the breadth, *viz.* about 0·046 mm. According to Waters (*op. cit.*, p. 242) the diameter of the organ is about 0·1 in *B. imbricata* "in an ordinary non-inflated condition." The anatomy of the polypide agrees closely with that of a specimen from the Irish Sea (Port Erin) lent me by Mr. F. H. Gravely, in particular in the structure of the gizzard. The figure of this organ reproduced on pl. xii, vol. VI of the *Records of the Indian Museum* (1911) for comparison with those of *Victorella* and *Hislopia* was drawn from Mr. Gravely's English specimen.

B. caudata, to judge from the few references[2] in literature to it, seems to be a scarce species in European waters. In India I have seen it only in the neighbour-

[1] *Journ. Linn. Soc.* (*Zool.*) XXXI, p. 241 (1910).

[2] For references see Waters, *op. cit.*, pp. 248, 249. Most of the works he cites are unfortunately not available in Calcutta.

hood of Port Canning in the Gangetic delta (where it is abundant with *Victorella bengalensis* in pools of brackish water) and at Rambha on the Chilka Lake. We did not find it in the lake itself, but in March, 1909, it was growing luxuriantly on water-plants of the genus *Nais* in pools of slightly brackish water near the shore. These pools have now become quite fresh, probably owing to the action of floods, and the Polyzoon has disappeared from them. *Bowerbankia caudata*, though it shares with other members of its genus the capacity of living in brackish water, is essentially a marine species and can only have reached the pools *viâ* the lake, in which its apparent non-occurrence is therefore somewhat remarkable.

Division *ALCYONELLEA*.

Family Alcyonidiidae.

Genus **ALCYONIDIUM**, Lamouroux.

Alcyonidium mytili, Dalyell.

1880. *Alcyonidium mytili*, Hincks, *Brit. Marine Polyzoa*, p. 498, pl. lxx, figs. 2, 3.

1905. *Alcyonidium mytili*, Thornely in Herdman's *Ceylon Pearl Fisheries* IV, p. 127.

Specimens from the Chilka Lake agree well with Hincks's figures. The polypides have as a rule 12 to 14 tentacles; Hincks says 15 to 18.

We found the species fairly common on shells of *Potamides* (*Tympanotonos*) *fluviatilis* at Satpara both in the fresh- and the salt-water season, and on those of *Purpura* (*Thais*) *carinifera* near the south end of the lake at all times of the year. So far as we could see it was always attached to shells that contained either hermit-crabs or their own proper inhabitants. Mr. T. Southwell recently captured at Diamond Harbour in the Hughli estuary a sea-snake (*Enhydrina valakadien*) to the skin of which numerous small circular colonies of this Polyzoon were attached. It would seem, therefore, that in the conditions prevalent in the Chilka Lake and in Indian estuaries it is advantageous for the organism to be attached to animals possessing the power of progression; but in Europe *A. mytili* has been found—as its name indicates—associated with sedentary molluscs, and also on algae, stones, etc.

The species is cosmopolitan.

ENTOPROCTA.

Family Urnatellidae.

1856. Urnatellidae, Allman, *Mon. Freshwater Polyzoa*, p. 117.

The family may be defined as follows:—

Deciduous colonial Entoprocta of fresh or brackish water that produce resting buds either by segmentation of the stalk or by the degeneration of a capitulum; that have a vertical or sloping lophophore with a well-developed web-like sphincter at its base, distinct tentacular retractors, a well-defined cloaca and a distinct water-vascular system.

Only two genera can at present be assigned to this family, namely *Urnatella*, Leidy, from fresh water in North America and *Loxosomatoides*, Annandale, from brackish water in India.

Genus **LOXOSOMATOIDES**, Annandale.

1908. *Loxosomatoides*, Annandale, *Rec. Ind. Mus.* II, p. 14.

Since this genus was described I have been able to compare specimens of *Urnatella* with the types. The relationship between the two genera is evidently very close and is shown even in the minute structure of the lophophore and tentacles and in the position of the different parts of the alimentary canal. I have not been able to detect any trace of a brood-pouch in *Loxosomatoides* and there is a distinct cloaca, most readily seen when the rectum is in a retracted condition. Spaces occur in the lophophore that are clearly homologous with the water-vascular system of *Urnatella* [1], and tentacular retractors are conspicuously present.

Urnatella, therefore, differs from *Loxosomatoides* mainly in the segmented stalk of its polyps and in not possessing either an elongate stolon or a chitinous capitular shield.

Nothing is known of the embryology of either genus, but the asexual method of reproduction is similar, though not identical, in the two. In *Urnatella* the stalks of the polyps segment to form resting buds, while in *Loxosomatoides* buds are formed by the degeneration of capitula. It is not yet certain whether any capitulum may degenerate for this purpose, or only certain capitula do so, and I have no information as to the stage in the development of the capitulum at which degeneration commences; but it is noteworthy that in one instance a stalk was observed which bore three resting buds, arranged in a linear series one in front of the other at its extremity. It is perhaps legitimate in any case to regard the capitulum in *Urnatella* as the homologue of a single segment of the stalk, or rather to conceive of the segment as a degenerate capitulum.

The species of *Loxosomatoides* that occurs in the Chilka Lake and the lagoons of Madras is not identical with the one described from the Gangetic delta, but the two are closely related. They may easily be distinguished one from the other by the complete absence from the capitular shield of the Peninsular species (*L. laevis*) of the spines that always occur on that of *L. colonialis*, and by the much more regular ornamentation of the shield in the former species. The normal method of growth is also different, for whereas the polyps in *L. laevis* are borne singly at considerable intervals on stalks that arise from one side of a slender rhizome which branches sparingly, in *L. colonialis*, though the unilateral arrangement also obtains, the polyps are arranged in groups and the rhizome from which their stalks arise is somewhat flattened and irregular and branches rather less sparingly. These characters are liable to be obscured if growth is congested or inhibited, but they never disappear altogether.

[1] Davenport, *Bull. Mus. Comp. Zool. Harvard* XXIV, pp. 1-44, pls. i-vi (1893).

Loxosomatoides colonialis, Annandale.

1908. *Loxosomatoides colonialis*, Annandale, *Rec. Ind. Mus.* II, pp. 14-19, figs. 2-7.

Except for what has been said under the generic heading, I have nothing to add to my original account of the species.

L. colonialis has been found as yet only in pools of brackish water at Port Canning in the Gangetic delta.

Loxosomatoides laevis, sp. nov.

In general structure this species closely resembles the preceding one, from which it differs mainly in the ornamentation of its capitular shield. The differences, however, appear to be quite constant, and I have seen no intermediate forms, though the number of examples examined in the field and in the laboratory has been large.

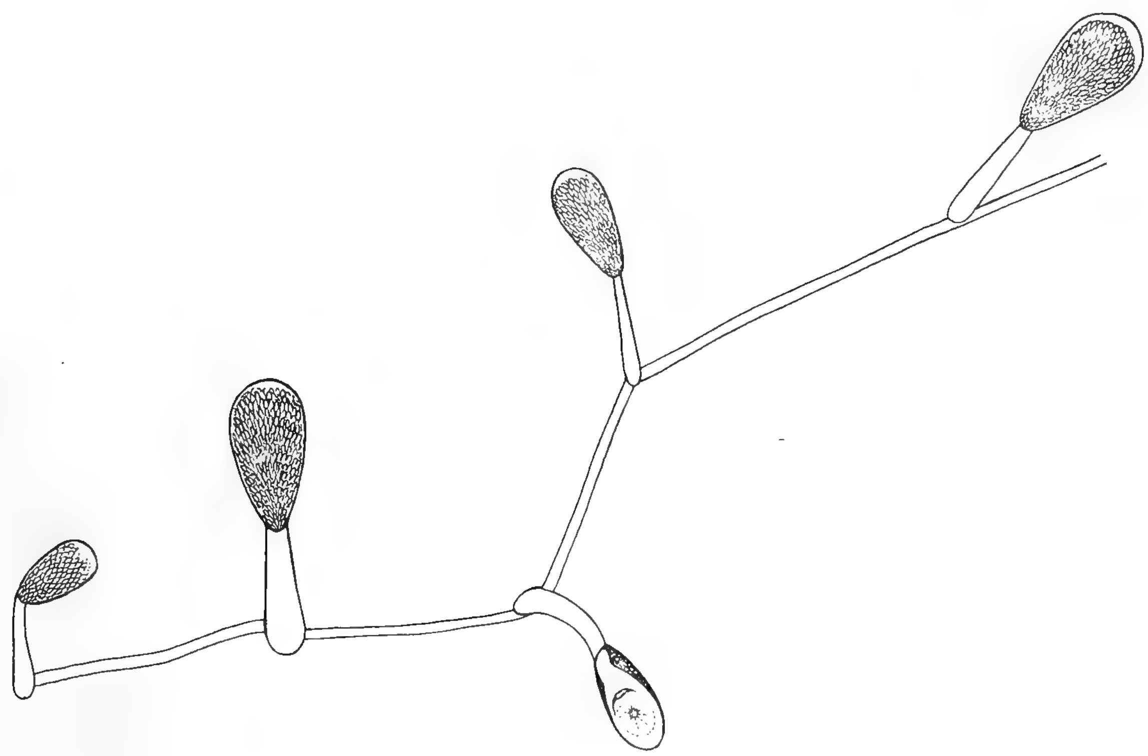


Fig. 1.—*Loxosomatoides laevis*, sp. nov.

Part of type specimen. One of the polyps has been turned back to show the oral surface.

The polyps (fig. 1) arise singly and at considerable intervals from a creeping rhizome that branches very sparingly or not at all. It grows mainly in one direction and follows the inequalities of the surface to which it is attached; the upper surface is convex, the lower surface flattened; its calibre is small and its surface smooth; it is never splayed out at the margins; the thin cuticle that covers it is usually colourless, but may be more or less tinged with brown.

The polyps all face in the same direction, away from the side of the rhizome to which the stalks of all of them are attached. The stalks are more or less swollen at the base and taper gradually; there is no specialized basal region. In normal

circumstances the stalk is very little if at all longer than the capitulum, but if the colony is overwhelmed by mud it may become greatly elongated; its cuticle is almost smooth and may be either colourless or have a distinct brownish tinge. The capitulum is rather narrowly ovoid, the blunter end being uppermost; in the opposite plane it is strongly compressed. When the lophophore is retracted, its direction is almost vertical, but when the tentacles are extended it slopes outwards and downwards in the same way as that of *L. colonialis* and *U. gracilis*. The normal number of tentacles appears to be 14.

The relative size of the capitulum shield varies considerably, but as a rule it does not completely cover the aboral surface, leaving bare a rim of variable width at the upper end. At the sides its margins are clear-cut; below the oral area they bend inwards towards the middle of the oral surface and are then obliquely truncated. There are never any spines on the shield; its ornamentation consists of numerous minute, closely compacted oval depressions arranged regularly in transverse rows. Those of the upper rows are a little larger than those nearer the narrowed basal

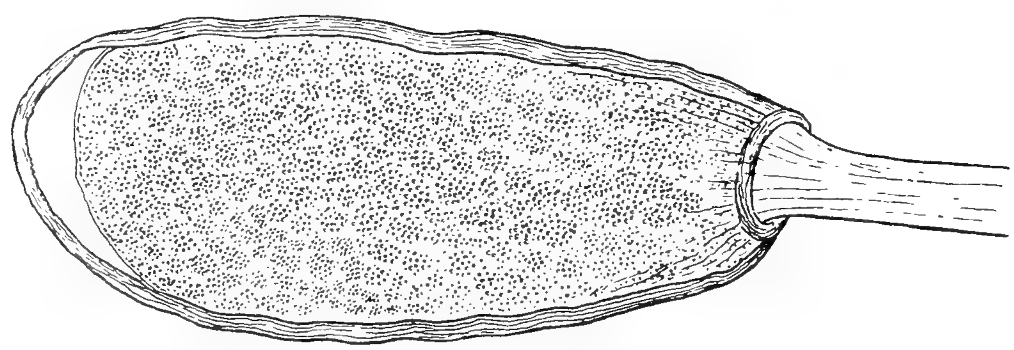


FIG. 2.—*Loxosomatoides laevis*, sp. nov.
Resting bud as seen from above in optical section, × 250.

extremity. The oral surface is completely devoid of spines or other armature and is always colourless. In life, as in spirit, the contrast between it and the shield, which is of a yellowish shade, is usually striking.

The length of the capitulum in the largest polyps is usually about 0·47 mm., the greatest breadth about 0·35 mm., and the thickness considerably less.

The most interesting fact ascertained with reference to the biology of this species was that of the production of resting buds. Seen from above these buds (fig. 2) closely resemble capitula lying, oral surface downwards, on the object to which the colony is attached. They are usually, however, rather narrower than ordinary capitula and their stalks, instead of standing upright or bending over in a semi-recumbent position, lie flat and adhere throughout their length. The upper surface of the bud is covered by a shield closely resembling that of a capitulum and ornamented in the same manner. At the broader end this shield is somewhat thinner and of a paler yellow. At the other extremity the bud bears a stout circular annulus of horny substance through which the stalk enters, the direction of this ring being at right angles to the surface on which it rests. The stalk, except in being

horizontal and adherent, resembles that of ordinary capitula. The lower surface of the bud is covered by a thin horny membrane that adheres to the object of attachment. The inner structure is very simple, consisting of a mass of circular cells filled with granular matter and contained in a delicate external epithelial membrane. Muscle-fibres can be seen making their way from the stalk into the proximal part of the cellular mass. There is a space at the broader end of the capsule. The granuliferous cells are not packed closely, but are separated by spaces that appear to be void of connecting substance. The length of the bud is about 0·27 and the breadth 0·15. It is thus smaller than the largest polyps.

I have found these buds on one occasion only, in the Ennur backwater in October, 1913. They take the place of ordinary polyps in the colony, but I cannot say whether they are produced by the degeneration of an ordinary active capitulum or by direct development. In the colonies in which they occurred I noticed that many

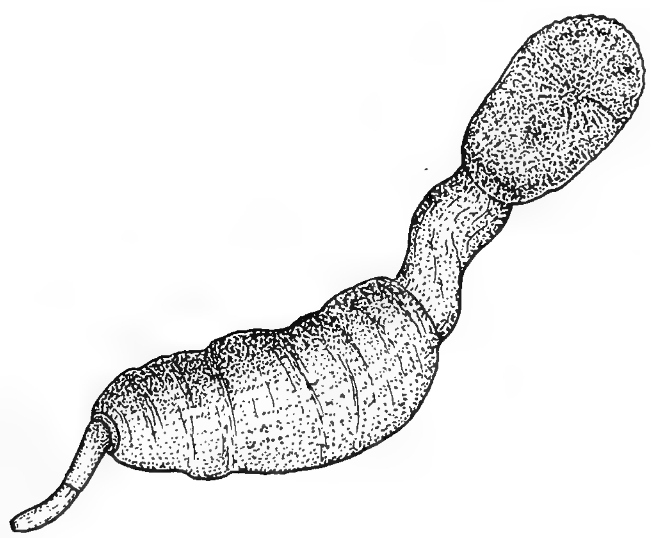


FIG. 3.—*Loxosomatoides laevis*, sp. nov.
Resting bud giving rise to a new colony, × 100.

normal polyps were lying prone on the surface of the oyster-shells to which they were attached, but this attitude is often adopted in normal circumstances, the shield being invariably uppermost. Among my specimens is one illustrating the origin of a young colony from a resting bud. It was in the substance of a thin encrusting Myxospongid sponge. This specimen is shown in fig. 3. The capsule of the bud has already degenerated somewhat, but traces of the characteristic ornamentation can still be detected under a high power. From the broader end a stalk bearing a young polyp has already emerged, while through the annulus at the other extremity a young stolon has made its way and is already producing at its tip the stalk of a polyp. It is evident that the original stalk of the bud had degenerated and disappeared; that this occurs commonly is substantiated by other specimens.

The polyps of *L. laevis* are very shy and I found it difficult to induce them to expand in captivity. When the lophophore was retracted they usually remained with the lower part of the stalk vertical and the upper part bent over in such a way

that the capitular shield was horizontal or had its broader end depressed. Sometimes, however, they lay quite prone as already indicated. The colonies were usually found either on stones or on oyster-shells, in both cases on protected surfaces, but they did not seem to avoid light so much as to seek protection from falling silt. In one instance we found a small colony on the stem of a water-plant. Its polyps did not differ from those of others. On stones the species was almost invariably associated with *Laxosuberites lacustris*, at the base of which its rhizome adhered, sending up the polyps through the substance of the sponge.

Though actually found in the Chilka Lake at three localities only, the species is evidently distributed widely in both divisions of the lake-system. The three localities were Barkuda Island and Gopkuda Bay in the main area and the oyster-beds of Manikpatna in the outer channel At the first and the last of these places it was abundant, but at Gopkuda Bay only one specimen was taken. The organism is so minute and inconspicuous that it very readily escapes observation, and it was probably owing to the fact that at Barkuda we were able (living in a bungalow close to the lake and having every facility for microscopic work) to make a very thorough investigation of the stones of the little landing-stage, that we found it in such abundance there. Oyster-shells also are naturally much more easily transferred to headquarters and examined in the field than stray pieces of rock. Apart from the Chilka Lake, the species has as yet been discovered only on the oyster-beds of the Ennur backwater a few miles up the coast from Madras. At Barkuda Id. the species was taken in an active condition at all times of the year, in water of specific gravity varying from 1·010 to 1·006; at Manikpatna we found it in March and September and at Ennur in November and January. It is thus clear that *L. laevis* can live in water of a specific gravity of at least 1·0265 and can survive, at any rate for a limited period, in pure fresh water.

The type (registered No. ZEV 6211/7) is preserved in the Indian Museum.

Family PEDICELLINIDAE.

Genus **BARENTSIA**, Hincks.

1880. *Barentsia*, Hincks, *Ann. Mag. Nat. Hist.* (5) VI, p. 285.
1886. *Cercopodaria*, Busk, *Rep. Zool. 'Challenger'* XVII (2), p. 41.

Barentsia discreta (Busk).

1886. *Cercopodaria discreta*, Busk, *Rep. Zool. 'Challenger'* XVII (2), p. 44, pl. x, figs. 6-12.
1905. *Cercopodaria discreta*, Thornely in Herdman's *Ceylon Pearl Fisheries* IV, p. 128.
1912. *Barentsia discreta*, Annandale, *Rec. Ind. Mus.* VII, p. 205.

In my note of 1912 I recorded the occurrence of a dwarfed form of this species in the Mutlah estuary at Port Canning in the Gangetic delta, the water containing

a saline residue of about 25·46 *per mille*, that is to say being almost as salt as that of the Bay of Bengal.

B. discreta was originally described from a depth of over 100 fathoms in the South Atlantic and was found subsequently by Professor Herdman in comparatively shallow water off Ceylon.

FAUNA OF THE CHILKA LAKE

CIRRIPEDIA.

By N. Annandale, *D.Sc., F.A.S.B.*

CONTENTS.

CIRRIPEDIA.

By N. ANNANDALE.

There is not much to be said about the barnacles of the Chilka Lake, for only two species, both of which are common and widely distributed, are represented, namely *Dichelaspis cor* and *Balanus amphitrite*. Both were found abundantly in the outer channel of the lake. The only species observed in the main area was *B. amphitrite*, of which a few individuals were noticed on rocks and the bottom of boats.

Dichelaspis cor probably breeds in the outer channel and this may also be the case with *Balanus amphitrite*, but larvae of the latter almost certainly enter annually from the sea. Both species were found in the adult state in the fresh- as well as the salt-water season.

No Rhizocephala or other true parasitic forms were found.

Suborder PEDUNCULATA.

Family LEPADIDAE.

In addition to the species discussed below, another member of this family (the common *Lepas anserifera*, Linn.) is represented by several specimens that were taken in a dead or moribund condition from a stick floating in the outer channel near Manikpatna in March, 1914 This species can hardly be included in the fauna of the lake on evidence so slight, for the stick had probably drifted in from the sea.

Dichelaspis cor, Aurivillius.

1909. *Dichelaspis cor*, Annandale, *Mem. Ind. Mus.* II, p. 119, pl. vi, figs. 7-10.

This species is common on the gills of the crab *Scylla serrata* in the outer channel at all times of the year. In the main area we failed to find it, though the crab was common. Some of our specimens are of very large size, the capitulum being 3 mm. in breadth and the peduncle 8 mm. long. All of them belong to Gruvel's var. A. *D. cor* has been found in the gill-chamber of *Panulirus* in the sea but is particularly common in that of *Scylla serrata* in estuarine tracts. Its distribution extends from East Africa to Sumatra.

The larvae are able to hatch from the egg and to live, at any rate for some hours, in pure fresh water. This I have seen in the case of specimens from the gills of crabs purchased in the Calcutta market. The adults which produced the eggs lived for at least twelve hours out of water.

Suborder OPERCULATA.

Family BALANIDAE.

Balanus amphitrite, Darwin.

1854. *Balanus amphitrite*, Darwin, *Mon. Cirripedia, Balanidae*, p. 240, pl. v, figs. *2a-2c*.

All our specimens from the Chilka Lake belong to Darwin's var. *communis*, but they vary considerably in shape, some being much more depressed than others. The largest have a diameter of about 15 mm.

The species is abundant on oyster-shells, fish-traps and wooden posts in the outer channel of the Chilka Lake and occurs singly or in small numbers on the shells of *Potamides* and other Gastropods and Lamellibranchs. In the main area a few solitary living individuals of small size were observed on rocks, mostly towards the end of the dry season, while a relatively large number of dead shells were observed in the same situation. On one occasion in the season of low salinity the bottom of a boat in Rambha Bay was found to be covered with small living individuals, but it had possibly arrived recently from the outer division of the lake-system. In the outer channel the specific gravity of the water in which apparently healthy barnacles were observed varied from 1·000 to 1·0265. I have seen them in brackish or almost fresh water in the Gangetic delta, near Madras and in Cochin on the west coast of India. The species is common in all the warmer seas and is carried into those of the northern temperate zone on the bottom of ships. In the Bay of Bengal it is perhaps the commonest of the littoral Operculata.

Larval *Balani*, probably of this species, were abundant in our tow-nettings taken in the outer channel in March. This is also the case in collections made in the same month in the shallower parts of the Bay of Bengal.

B. amphitrite is remarkable for the rapidity of its growth and for its power of resisting unfavourable circumstances. Professor Herdman[1] found specimens of a diameter of 8 mm. on baskets that had been in the sea off Ceylon for 21 days. I have little doubt that the species breeds regularly in the outer channel of the Chilka Lake and that stray larvae are carried into the main area and occasionally find it possible to settle down and undergo their metamorphosis, without being able to survive it for more than a few months.

The vicissitudes undergone annually by barnacles attached to oyster-shells in the outer channel are sufficient proof of the strong vitality of the species, but even more remarkable evidence is afforded by the fate of those individuals that attach themselves to prawn-traps in the neighbourhood of Satpara. The traps are placed in the lake in the evening and, remaining in the water all night, are removed at dawn. Throughout the heat of the day they lie on the shore, fully exposed to the sun's rays. Nevertheless, the barnacles on them survive. We saw many instances of this, more particularly in September, 1913, and in the same month of 1914. Specimens from such situations are small (not exceeding 9 mm. in diameter) and dull in colour, but otherwise apparently normal.

[1] *Ceylon Pearl Fisheries* V, p. 147 (1906). The dates were April 17th to May 9th.

FAUNA OF THE CHILKA LAKE

OLIGOCHAETA.

By J. Stephenson, *M.B., D.Sc., Lieut.-Col., I.M.S., Professor of Zoology, Government College, Lahore.*

(Plate X).

CONTENTS.

OLIGOCHAETA.

By J. Stephenson.

The Oligochaeta of brackish water are few, and do not form an independent ethological group. They seem to be forms belonging to the freshwater or littoral groups which possess the power of resisting a certain amount of admixture of salt or fresh water respectively.

Though the Oligochaeta have long been recognized as capable of contributing valuable results to zoogeography, these results have been gained almost entirely from a study of the terrestrial forms, to the exclusion of those of aquatic and littoral habit. Nor in view of the modes of dispersal can it be expected that it will be otherwise in the future. The following few remarks may serve briefly to illustrate this statement.

In the case of freshwater forms, it seems probable that birds are one of the chief agents of dispersal; the mud which adheres to the feet of waders offers an easy means of transport to small worms or their cocoons; and it is well known that small animals, such as Nematodes and Rotifers, have been cultivated from such mud after a prolonged flight, while small molluscs have also been found to be conveyed in this way. Speaking of the probable introduction of Australian worms into New Zealand in this way, Benham ("A note on the Oligochaeta of the New Zealand Lakes", *Trans. N. Z. Inst.*, XXXVI, 1903) calculates that a strong flier with the wind behind it could cover the distance in 36 to 48 hours. The comparative valuelessness for zoogeography of the data of distribution of freshwater Oligochaeta may be exemplified by the fact that *Nais paraguayensis*, first found, as the name implies, in material from Paraguay, has since been discovered in Lahore; that *Nais communis*, described first from Switzerland, has been found both in North and South India; *Stylaria lacustris*, also found at Lahore, occurs all over Europe, in the Baikal Sea, and in North America; while the genus *Chaetogaster*, represented by several species in India, is found throughout Europe, in North America, in the Baikal Sea, and in Australia, and is indeed probably absolutely cosmopolitan.

The littoral Oligochaeta are unfortunately capable of furnishing no more valuable results. "The animals usually lay their cocoons underneath and amongst the masses of detritus on the shore, often attaching them firmly to these......When at more than usually high tides these masses are again washed into the sea, they may be taken up by currents, carried far away, and thrown up with the cocoons they bear on to the shore at some distant point. In this way littoral Oligochaetes may spread not only along a continuous coast-line but over considerable stretches of

ocean. Probably shore-birds also contribute to their dispersal by carrying away cocoons which adhere in a chance manner to their feet. That such a trans-oceanic dispersal of littoral Oligochaeta is a fact may be seen from the case of geologically recent and isolated oceanic islands; these contain (apart from forms demonstrably introduced by man) no terrestrial Oligochaeta, but are colonized by littoral species, *e.g.* the small coral island Laysan of the Hawaiian Archipelago by a species of *Pontodrilus*" (Michaelsen, *Die geographische Verbreitung der Oligochaeten*, 1903). So the genus *Pontodrilus* is apparently distributed over the coasts of all the warmer portions of the globe; while *Enchytraeus albidus* is found from Nova Zembla and Greenland to South Patagonia and Kerguelen Is.

Family ENCHYTRAEIDAE.

Genus **ENCHYTRAEUS**, Henle.

Enchytraeus barkudensis, sp. nov.

(Plate X, figs. 1-4.)

Types.—Barkuda Island, Chilka Lake, Ganjam Dist., Madras Presidency. In sand at edge of lake; 16-vii-1914. Five specimens (Reg. No. ZEV 6545/7, *Ind. Mus.*).

Length 15 mm. Filiform, breadth about ·3 mm. Colour light brown. Segments 57-64.

The prostomium is rounded and very short.

The *setae* are of the same type (*Enchytraeus* type) in both lateral and ventral bundles; they are blunt rods, straight except for a curve at the inner or proximal end. In both lateral and ventral bundles they are three per bundle in segments ii—xi; segment xii has lateral bundles consisting each of two setae, but no ventral bundles; from segment xiii onwards the setae are two per bundle, both laterally and ventrally.

The *clitellum* is not distinguishable.

Not much of the anatomy of the worms could be observed with accuracy in the entire specimens, and most of the following account is based on the examination of longitudinal sections.

The *septa* in the anterior region are much bulged backwards, especially 7/8, 8/9, and 9/10, which form deep pockets filled with coelomic corpuscles. These three septa are also considerably thickened as compared with the others, and form stout sheets of muscular fibres (*cf.* septum 9/10 in fig. 2).

The *coelomic corpuscles* (fig. 2) are numerous and conspicuous even in the entire animal; they are nucleated flattened plates, oval or broadly spindle-shaped, of an average length (in the fixed and stained condition) of 28μ; the maximum length observed was 41μ.

The *pharynx* (fig. 1) occupies segments ii and iii; it has the usual constitution, the epithelium of the roof being markedly columnar and forming a sucker-like plate. The *oesophagus* is a narrow and uniform straight tube, ciliated throughout, and showing no differentiation; it passes fairly suddenly into the *intestine*, distinguish-

able by its greater width, in segment xv (in one specimen), xvi or perhaps xvii (in a second).

The *salivary glands* (fig. 1) are apparently represented by a pair of short club-shaped backwardly directed evaginations of the pharynx; these take origin from the hinder part of the pharyngeal roof, behind the sucker-like epithelial plate, and are situated one on each side near the middle line.

The *septal glands* are situated on the anterior faces of septa 4/5, 5/6, and 6/7, causing these to bulge backwards. Those of each pair are continuous dorsally over the oesophagus; and each gland is continued forwards by an anteriorly projecting lobe situated ventro-laterally to the oesophagus. In entire specimens the glands appear to be in segments v, vi, and vii, and perhaps to be more than a single pair per segment; but the appearances are explained by the backward bulging of the septa, and the presence of the anterior lobes, as just described.

The *dorsal vessel* is certainly distinct as far back as segment xv,—probably further, as far as xvi, if not xvii.

The *nephridia* have a short ante-septal portion,—perhaps a quarter the length of the postseptal; the post-septal portion is elongated, narrow, and gives off the duct from its under surface at about one-third of its length from the posterior end; the duct is short, passes vertically downwards, and ends in front of the ventral setae.

The *cerebral ganglion* is in segment i; its shape could not be determined.

The description of the male genital organs (figs. 2, 3, 4) is most conveniently begun with the *sperm-sacs*. These are two in number, quite distinct from each other, of large size and ovoid shape (figs. 2, 3); they are continuous with and suspended by septum 10/11; they project forwards into segment x, and, still more, backwards into xi, so that they occupy the whole length of the latter segment; their walls are quite thin, but complete. Contained within this sac is a large mass of sperm-morulae, in various stages of development; but, in the two specimens which were sectioned, there were no wisps of fully developed spermatozoa. What is to be considered as the *testis* is a mass of cells (figs. 2, 3), adherent to the inner face of the sac-wall at its lower part, *i.e.* to the floor of the sac, approximately in the region where septum 10/11 joins it. This mass of cells may project not inconsiderably into the interior of the sac; or it may constitute merely a flattened plate, perhaps divided up into a number of smaller masses. The morulae within the sac are evidently developed from cells which are proliferated from the cell-mass or cell-plate; indeed there is a gradual transition from the one to the other. The *funnel* (fig. 4) is in segment xi; it is two or three times as long as broad; it has the usual cylindrical shape, but the cells of which it is composed have not the usual clear mucous appearance in stained sections; this might possibly be due to the specimens being in a rather early stage of sexual maturity. The *vas deferens* is situated in segment xii; it is long, thin, 16μ in diameter, and coiled; fig. 4, sketched from an entire specimen in cedar oil, will give an idea as to its disposition and course. The *penial body* is a small hemispherical mass of cells round the termination of the *vas*

deferens, which latter pierces through it without interruption and reaches the surface at the position of the (absent) ventral setae of xii.

The *ovaries*, and masses of *ova*, are contained in segment xii. Funnels and oviducts were not observed.

The *spermathecae* are in segment v, and communicate with the oesophagus. The ampulla is small, ovoid in shape, 50μ in diameter; the duct is a narrow tube, 14μ in diameter, of considerable length and with a few slight bends in its course. There were no spermatozoa in the ampullae.

This little worm is stated to be practically colourless in life, but rather opaque.

The discovery of the present species is of interest in several ways. Though (like the Tubificidae) occurring in such abundance in the temperate regions of Europe, the Enchytraeidae seem to be very rare in India; the present is the fourth species which has been completely investigated. This rarity is probably partly apparent, partly real; and the same may be said of the Tubificidae also, of which too only four species have been recorded.

A feature that is worthy of note is the presence of sperm-sacs. These are not invariably present in the genus *Enchytraeus*; out of the two other Indian species of the genus they are absent in one (*E. indicus*), present in the other (*E. harurami*). In the present species the sacs are of the same nature as those of *E. harurami*, and differ from those of the Naididae and of the genus *Mesenchytraeus*, the only other Enchytraeid genus in which they are found. In *Mesenchytraeus* and the Naididae the sacs are pocket-like backward extensions of the septum which forms the posterior wall of the testis segment; here they are closed bags, seated on or suspended from the anterior wall of the segment, and containing both testis and developing sperm-morulae. The sacs do not include the funnels of the vasa deferentia; and since they are, in the stages at which I have examined them, completely closed, it is not obvious how the spermatozoa escape (*cf.* remarks on *E. harurami*, in a previous paper: "On a collection of Oligochaeta, mainly from Northern India", *Rec. Ind. Mus.*, vol. x, p. 321, 1914).

Another point of interest is the condition of the salivary glands ("peptonephridia"). In the species in which they occur, they are found usually as narrow curling tubes extending back for a few segments behind the pharynx, from the posterior end of which they take origin. In the present case there are a pair of small club-shaped structures, quite short and inconspicuous, discovered in the series of longitudinal sections, though they would probably have escaped notice during life; these originate from the posterior end of the pharynx, and seem to correspond to the salivary glands of other forms. Similar rudimentary salivary glands appear to have been described by Ude ("Beiträge zur Kenntnis der Enchyträiden und Lumbriciden", *Zeit. f. wiss. Zool.*, vol. 61, 1895) in *Bryodrilus ehlersi*, though I have not seen the original paper.

The above characters, together with the setal distribution, are sufficient to distinguish the form as a new species.

E. barkudensis was found at only one spot in the Chilka Lake, namely in a small patch of sand at one side of the landing-stage on Barkuda Id., in the main area. It lives there, with *Pontodrilus bermudensis* f. *ephippiger*, some inches below the surface and well below water-level. The months in which specimens were obtained were July and November. In the former the specific gravity (corrected) of the water immediately off Barkuda Id. was 1·015, while in November it was 1·005. The species was taken in January at the edge of the Ennur backwater near Madras, also in wet sand and with *P. bermudensis*, the specific gravity of the water being about 1·0025. On all three occasions sexually mature worms were obtained.

Family MEGASCOLECIDAE.

Genus PONTODRILUS, E. Perrier.

Pontodrilus bermudensis, Bedd., forma **ephippiger** (Rosa).

1914. *Pontodrilus ephippiger*, Stephenson, *Rec. Ind. Mus.* X, p. 256.

In life this worm has a bright pink colour.

In the Chilka Lake specimens were obtained both in the main area and in the outer channel at all times of the year. They occurred at the extreme margin in wet sand or sand mixed with mud, sometimes under stones with the amphibious Isopoda *Hemiporcellio carinatus* and *Arhina barkulensis*, Collinge,[1] the water being either fresh, brackish or as salt as that of the Bay of Bengal. Probably, however, the species does not breed in fresh water, as no fully mature individuals were found in the fresh-water season (July to September). The chief breeding-time seems to fall in late winter and early spring, when the water of the lake varies in corrected specific gravity from 1·008 to 1·026. At the edge of the Ennur backwater near Madras the same form was found in January, 1915, in sand wetted by water of specific gravity of about 1·0025. Some of the specimens were mature.

The species is very widely distributed on the warmer coasts of both hemispheres. Following Michaelsen (*Mitt. aus dem Naturh. Mus. Hamb.*, xxvii, 1909) I now recognize *P. ephippiger*, Rosa, as one of the numerous forms of *P. bermudensis*, Bedd. The form *ephippiger* is recorded from Christmas I., Celebes, and the Hawaiian Archipelago; the form *insularis* of the same species (formerly *P. insularis*, Rosa) has been found, among other places, in Ceylon.

Family GLOSSOSCOLECIDAE.

Genus CRIODRILUS (Hoffmstr.).

Criodrilus lacuum, Hoffmstr.

1914. *Criodrilus lacuum*, Stephenson, *Rec. Ind. Mus.* X, p. 256.

The identification of this worm is, as stated in the above paper, not absolutely certain, since the specimens were not fully mature.

The natural colour of this worm is tinged with a peculiar ochraceous shade.

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[1] *Rec. Ind. Mus.* XI, pp. 145, 147, pls. vi, viii (1915).

The species is apparently common on the shore of the Chilka Lake somewhere near Satpara, where the beach is for the most part sandy. It is dug for bait by fishermen. Specimens obtained from them in March, 1914 were not quite mature. The corrected specific gravity of water from the lake at Satpara was in this month 1·026. In Palestine the worm lives in wet earth under stones at the edge of water.

This is a well-known European species, which occurs throughout Central Europe, in S. Russia, Syria and Palestine. It is interesting to find it in brackish water, since it is a typically limnic form, and so far as I know has not hitherto been recognized as littoral. That it can support a considerable amount of salt is, however, shown by its occurrence on the margin of the Lake of Tiberias, the water of which is markedly saline; and this being the case, it is perhaps remarkable that it has not so far definitely established itself as a littoral form.

EXPLANATION OF PLATE X.

Enchytraeus barkudensis, sp. nov.

Fig. 1. Longitudinal section through pharynx and part of oesophagus, a little to one side of the median plane, and cutting the club-shaped salivary gland; × 145.

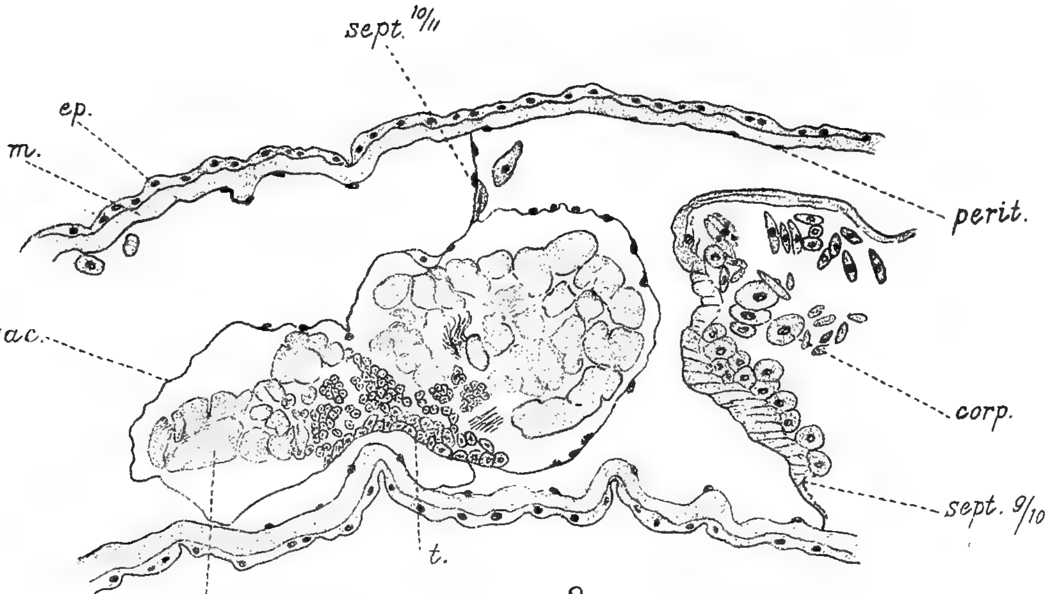
Fig. 2. Longitudinal section passing to one side of the alimentary canal in segments x and xi, and showing the sperm-sac suspended by septum 10/11, the testis being constituted by a proliferation of cells on its inner wall; × 190.

Fig. 3. Ventral half of a similar section, nearer the middle line, showing the relations of the sperm-sac below the oesophagus (the portion of the section here shown is bounded above by the ventral wall of the oesophagus); × 190.

Fig. 4. Male deferrent apparatus, sketched from an entire specimen in cedar oil.

Cil. ep., ciliated epithelium of ventral wall of oesophagus; *d.v.*, dorsal vessel; *ep.*, surface epithelium; *f.*, male funnel; *m.*, muscular coat of body-wall; *mor.*, sperm-morulae; *m. ph.*, muscular bands of the pharynx, mostly retractors; *oes.*, oesophagus; *p.b.*, penial body; *perit.*, peritoneal cells or nuclei; *ph.*, pharynx; *sac.*, sperm-sac; *sal.*, salivary gland (so-called "peptonephridium"); *sept.* 9/10, 10/11, 11/12, septa; *t.*, testis; *v.d.*, vas deferens; *v.v.*, ventral vessel.

FIGS. 1, 2 and 3 drawn by Abbe's drawing apparatus (Zeiss).



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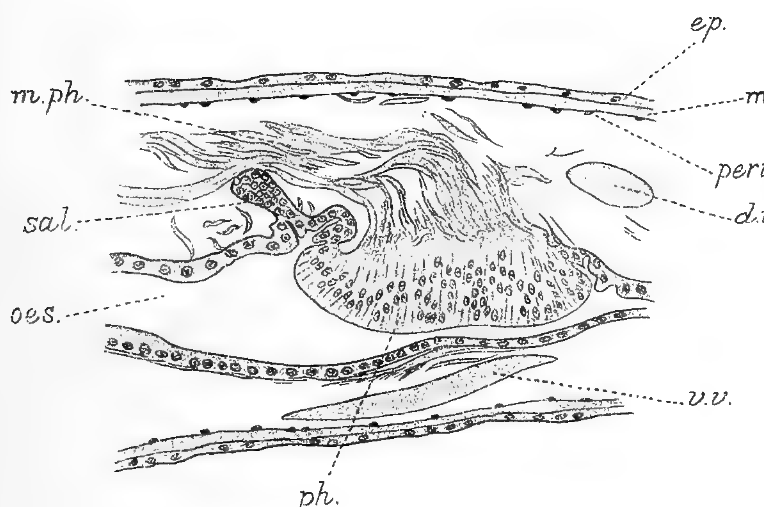

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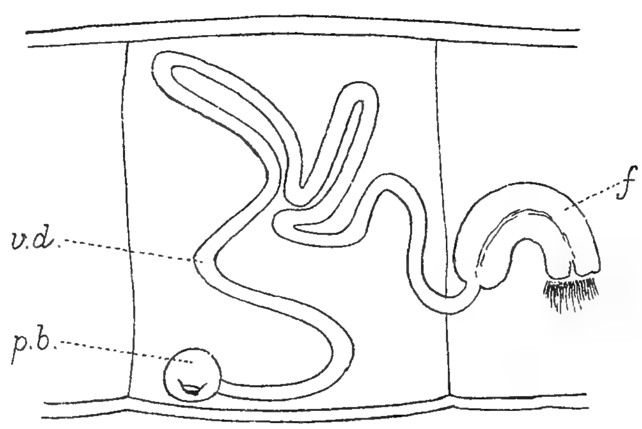

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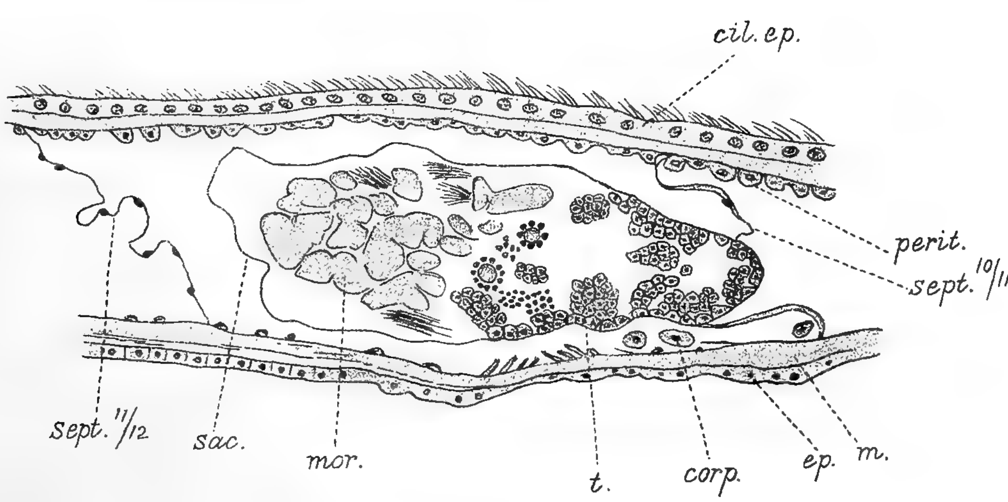

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A. Chowdhary, lith.

OLIGOCHAETA OF THE CHILKA LAKE.

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FAUNA OF THE CHILKA LAKE

THE MYSIDACEA OF THE LAKE, WITH THE DESCRIPTION OF A SPECIES FROM THE COAST OF ORISSA.

By WALTER M. TATTERSALL, *D.Sc., Keeper of the Manchester Museum.*

(With 1 text-figure.)

CONTENTS.

MYSIDACEA.

By WALTER M. TATTERSALL.

Dr. Annandale and Mr. Kemp have continued to send me further collections of Mysidae made by them in various parts of the littoral of India, mainly in brackish water. In the present paper I describe two new species, belonging to the genus *Gastrosaccus*, and record a third one, *Rhopalophthalmus egregius*, Hansen (previously known from Japan and the East Indies) for the first time from the coast of India, where it appears to be an abundant form. The number of species of Indian brackish water Mysidae is now raised to five and Dr. Annandale and Mr. Kemp are to be congratulated on the success which has attended their work. My best thanks are due to them for the opportunity of examining and reporting on these specimens.

The majority of the specimens here recorded are from the Chilka Lake, a shallow lagoon on the east coast of India, some thirty miles long and ten miles broad, connected with the sea by a narrow mouth. The salinity of the water in this lake differs very greatly at different seasons of the year,[1] and Mr. Kemp informs me in a letter that "visiting the lake in September (1914) at a time when the water is at its highest, we found that a considerable part of the lake, including the outer channel as far as the sea-mouth, was filled with absolutely fresh water. A great part of the fauna of the lake is thus able for some two or three months each year to exist in perfectly fresh water, and many species exist in salinities ranging from fresh water to water as salt as the Bay of Bengal (sp. gr. 1·0265)." Among such species are all but one of the Mysidae here dealt with, and it is exceedingly interesting to find that they have adapted themselves to such a changing environment. In connection with one of the species, *Potamomysis assimilis*, I have suggested that the great changes in the salinity of the sea-water may account for the relatively great variation in the shape and armature of the telson, but in order to settle this question, a complete series of specimens, taken regularly throughout the year, with notes on the salinity of the water at the time of capture would be necessary. It is possible that the changes in salinity are too rapid to allow of correlated changes in the structure of the species. The other two abundant species, *Macropsis orientalis* and *Rhopalophthalmus egregius*, do not show evidence of such variation.

Of the five species of Mysidae now known from brackish water in India four occur in the Chilka Lake. Three of these (*Rhopalophthalmus egregius*, *Macropsis orientalis*

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[1] See Introduction, p. 5.

and *Potamomysis assimilis*) are very abundant in all parts of the lake, the main area as well as the outer channel; while one (*Gastrosaccus muticus*) has been found less com monly in the outer channel and adjacent parts of the main area. The fifth species (*Indomysis annandalei*) is at present known only from the neighbourhood of Bombay

The following key will serve for the identification of the known species of Indian brackish-water Mysidae.

KEY TO THE SPECIES OF INDIAN BRACKISH-WATER MYSIDAE.

1. Both rami of the uropods divided by a transverse joint distal to the centre.
   Thoracic legs without terminal brush of setae: dactylus not developed; pleopods of the male well developed, exopod of the second pair very elongated, rami of the third, fourth and fifth pairs subequal.
      Telson entire, apex armed with four strong stout serrate spines: distal half of the lateral margins armed with about fifteen spines: antennal scale as long as the antennular peduncle with the outer margin entire (*i e.*, without setae) and terminating in a spine, six times as long as broad: carapace very short: eyes large, black, on prominent stalks: eighth thoracic limb in both sexes with the endopod reduced and papilliform .. .. *Rhopalophthalmus egregius*, Hansen.
2. Both of the uropods undivided.
   (*a*) Outer margin of the exopod of the uropods armed with more or fewer spines, but without setae between the spines and the base: third pair of pleopods of the male with the exopod elongated: first abdominal segment of the female with a pair of lateral lamellae: telson long, as compared with the uropods, cleft at the apex, the cleft armed with sharp serrations.
      Lateral margins of the telson armed with about fourteen spines: no spine on the dorsal surface of the fifth segment of the pleon: posterior dorsal margin of the carapace with a fringe of from six to nine slender processes: exopod of the third pleopod of the male as described in this paper .. .. *Gastrosaccus muticus*, W.M.T.
   (*b*) Outer margin of the exopod of the uropods setose, without spines: first abdominal segment of the female without lateral lamellae: telson short, entire, without apical cleft.
   (*c*) Apex of the telson between the terminal spines of the lateral margins truncate, armed with numerous short spines: first, second and third pleopods of the male rudimentary as in the female, exopod of the fourth pair elongate: antennal scale setose all round.
      (1) Antennal scale two-jointed, about seven times as long as broad; lateral margin of the telson armed with 7-10 spines, apex with 12-17 spines not much shorter than the terminal spine of the lateral margin .. *Potamomysis assimilis*, W.M.T.
      (2) Antennal scale unjointed, about $4\frac{1}{2}$ times as long as

broad; lateral margins of the telson armed with 4-7 spines, apex with numerous quite small spines or teeth much shorter than the terminal spines of the lateral margins .. .. .. *Indomysis annandalei*, W.M.T.

(*d*) Apex of the telson between the terminal spines of the lateral margins produced into an obtuse serrated process; third pleopod of the male biramous though small; exopod of the fourth pair elongate; antennal scale setose all round and two-jointed; eyes rather large on long stalks . .. *Macropsis orientalis*, W.M.T.

One species (*Gastrosaccus simulans*) described in this paper, was not found in brackish water, but on the sea-shore a few miles up the coast from the mouth of the Chilka Lake.

Dr. Annandale and Mr. Kemp have supplied notes on the natural colouration, habits, etc., of the different species. These notes I have added in each case at the end of my own observations.

Family MYSIDAE.

Sub-family *RHOPALOPHTHALMINAE*, Hansen.

Genus **RHOPALOPHTHALMUS**, Illig.

Rhopalophthalmus egregius, Hansen.

R. egregius, Hansen, 1910. *R. egregius*, Nakazawa, 1910.

This interesting species was first described by Hansen (1910) from specimens taken on the Siboga expedition in the Sangkapoera Roads, Bawean Island, in the East Indies. It has since been recorded by Nakazawa (1910), from Port Shimizu, Suruga Bay, Japan. Its occurrence on the coast of India therefore marks a considerable extension in its known geographical range, and it is evidently an abundant and widely distributed form.

Hansen's description was based on mutilated specimens, and is therefore incomplete. I am able from the present material to supplement his description and to add some points not hitherto noticed.

The most interesting feature of the species, not noticed by Hansen but described and figured by Nakazawa, is the reduced condition of the endopod of the eighth pair of thoracic limbs in both sexes. In the female, the endopod of these limbs is hardly as long as the basal joint of the exopod, papilliform in shape, obscurely two-jointed, with one or two setae on the outer edge at the obscure junction of the two joints, but otherwise unarmed. In the male, the endopod is more distinctly two-jointed, and the basal joint bear six long setae on its outer margin.

The remainder of the thoracic legs are as described by Hansen. They increase in length and slenderness from the third to the seventh pair and have the sixth joint or tarsus four-jointed in the third pair, five-jointed in the fourth to the sixth pair and seven-jointed in the seventh pair. The carapace is exceedingly short, leaving entirely exposed the last three thoracic segments. The antennular peduncle appears to me to be somewhat stouter than shown in Hansen's figure and has the outer distal

corner of the basal joint more produced. The distal part of the outer margin of the basal joint is armed with numerous long plumose setae in the position indicated by the notches in Hansen's figure and as depicted by Nakazawa.

The antennal scale, which reaches to the distal end of the antennular peduncle, is as figured by Hansen, but the basal joint from which both the scale and antennal peduncle spring, is armed with three strong spines at the inner corner, at the base of the peduncle. These spines are not indicated by either Hansen or Nakazawa. The antennal peduncle is very short, not as long as the basal joint of the antennular peduncle. The Indian examples reach a length of 12 mm.

The natural colouration of this species is described as follows:—Transparent, with a large lateral patch of very pale mauve on each abdominal segment. Brood-pouch tinged with yellow. Two blood-red spots on the telson, one at the base and one near the apex. Eyes pale glaucous green.

Rhopalophthalmus egregius occurs abundantly all over the Chilka Lake, especially on a muddy bottom and among the weed *Halophila ovata*. It has, however, also been taken on clean sandy ground. Although taken at Barkuda Id. within a few yards of the shore, it was usually captured out in the lake in water from 4 to 12 ft. deep. It was never observed close in to the rocks or in very shallow water, and in this respect its habits differ markedly from those of *Macropsis orientalis* and *Potamomysis assimilis*. Apparently it lives mainly at some distance below the surface, perhaps only a few inches above the bottom. The species is gregarious.

Sub-family *GASTROSACCINAE*, Norman.

Genus **GASTROSACCUS**, Norman.

Gastrosaccus muticus, sp. nov.

Locality.—Outer parts of Chilka Lake, Orissa, E. coast of India.

Description.—Very closely allied to *Gastrosaccus spinifer*, Goës.

Dorsal posterior median emarginate border of the carapace with a fringe of from six to nine slender filaments.

Fifth segment of the pleon without a dorsal spine-like projection.

Antennules with three or four short strong spines on the outer edge of the second joint; a single similar spine on the outer edge of the third joint about one-quarter of the length of the joint from the distal end.

Antennal scale reaching to the distal end of the second joint of the antennular peduncle and slightly shorter than its own peduncle; slightly less than four times as long as broad, outer margin terminating in a strong spine beyond which the apex of the scale is not produced.

Telson less than three times as long as broad at its base, with about fourteen spines on its outer margin, only the terminal spines conspicuously larger than any of the remainder and equal in length to one-eighth of the length of the telson; telson cleft for one-sixth of its length.

Inner uropods equal in length to the telson plus its terminal spines, with four

somewhat distantly placed spines on its inner margin, the proximal one of which is on the statocyst.

Large epimeral plate of the first segment of the pleon in the female with its front margin microscopically serrulate.

Tarsi of the third to the eighth thoracic limbs composed of from seven joints in the third pair to eleven joints in the eighth pair. Basal joint of the exopodites of all the thoracic limbs with a prominent tooth at its outer distal corner, except in the eighth pair where this corner is rounded.

Pleopods of the female very similar to those in *G. spinifer* except that the two branches of the first pair are more nearly equal in size than shown in Stebbing's figure (1880).

First, second, fourth and fifth pleopods of the male agreeing closely with those figured by Sars (1877) for *G. sanctus*. With the exception that the exopod of the first pair is eight-jointed, both the exopod and the endopod of the second pair are eight-jointed, and the endopod of the fourth and fifth pairs is seven-jointed, Sars' figures would serve very well to illustrate the present species. The agreement in the general form and proportions is of the closest character.

The third pleopods of the male differ vastly from those of the male of *G. sanctus*. The endopod is similar to that of the preceding and succeeding pairs, seven-jointed, and extending about half way down the second joint of the exopod. The exopod is very elongate, reaching to the base of the telson and divided into five joints. The first joint shows three suture lines representing subsidiary joints, similar to those shown in Sars' figure (1877) of the same appendage of *G. sanctus*. The second joint is shorter than the first, and the third joint is as long as the first and second combined but more slender. The fourth joint is short and has the distal lower margin produced into an obtuse lobe. The terminal joint is longer than the fourth and broadens considerably to an obliquely truncate apex. At one corner of the apex are two short stout spines terminating in two processes, the outer one rather stout and blunt and microscopically ridged, the inner one slender and acutely pointed. At the other corner of the apex is placed a long, strong, slightly curved spine with about eleven spinules on the distal half of its margin. At the base of this long curved spine is situated a smaller, more slender and more sharply curved spine and between this latter spine and the two spines with the bifid apices, there is an obtusely pointed process, microscopically ridged at its apex, which arises from some way inside the distal margin of the fifth joint, on its lower face. The whole of the fifth joint resembles a sub-chelate "hand" with the bifid spines delimitating the palm on one corner, and the long curved spine as the "finger."

Length of an adult female, 7 mm.; of an adult male, 6 mm.

This species is very closely allied to *G. spinifer*, Goës, but differs in the following points :—

(1) The absence of the dorsal spiniform process on the fifth segment of the pleon.

(2) The larger number of spines on the lateral margins of the telson, fourteen as against six to eight in *G. spinifer*.

(3) The fewer spines on the inner margin of the inner uropods, four as against nine to eleven in *G. spinifer* [1].

(4) In having four spines on the outer edge of the second joint of the antennular peduncle instead of three as in *G. spinifer*.

(5) In its smaller size, 7 mm., as against 20 mm.

(6) In the vastly different form of the exopod of the third pleopods of the male. The third pleopod of the male of *G. spinifer* has never been figured, but I find by examination of British specimens that it agrees closely with the same appendage in *G. sanctus* as figured by Sars (1877).

In the possession of a fringe of slender filaments on the central posterior dorsal margin of the carapace, *G. muticus* is at once distinguished from all other described species of the genus except *G. spinifer* and the following new form.

In life the species is described as being not very translucent, with a large brown spot at the base of the lower antenna and another, posterior to the first, near the hinder end of the carapace. Each of these dark spots was connected with a pale yellowish one situated above it. There were two small black spots on each side of the brood-pouch, consisting of single dendritic chromatophores. On the posterior margin of each of the abdominal segments there was a brown dendritic chromatophore on either side, connected with its fellow on the opposite side by a yellow line. The last abdominal segment bore a brown transverse bar at its posterior extremity. The telson was tipped with mingled brown and yellow. The tip of the antennal scale was brown. The eggs were quite colourless.

G. muticus occurs mainly in the outer channel of the Chilka Lake, but was also taken near Nalbano in the main area. It was invariably found either on a sandy bottom or on one in which the mud was mixed with a considerable amount of sand. Although considerable numbers of specimens were sometimes taken in a single haul of the ⌓-net, the species is perhaps less markedly gregarious than the others found in the lake.

The type specimens are preserved in the Indian Museum and are numbered 8664/10 in the Museum register.

Since this paper went to press, I have received specimens of this species from Madras, where they were collected by Dr. Annandale in the Ennur backwater, in water of specific gravity varying from 1·000 to 1·0045 (corrected). The species was apparently quite abundant in this locality.

Since this paper left my hands, I have received further material of this species from the Chilka Lake, and its examination necessitates the following additional notes. The material altogether comprised 24 males and 46 females. A point of perhaps minor importance is that the number of spines on the outer margin of the second joint of the antennular peduncle is not invariably four. Quite a number of the specimens in this additional material have only three spines in this position. The main interest centres in the form of the exopod of the third pleopods of the male.

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[1] There is apparently some variation in this character.

Of the male specimens fifteen are adult and have the exopod of the third pleopods as I have described it above. This may for convenience be known as form A. Two of the males, while apparently adult (that is, they are quite as big as the other specimens and are apparently, therefore, fully grown) have the exopod of the third pleopods of a quite different form, which may be known as form B (fig. 1*d*, p. 157). The last two joints are longer and not so stout as in form A and the bifid spine-like processes are absent, being replaced by two simple spines. The single microscopically ridged process is present as in form A, and the terminal curved spine is of the same proportional length. In all other characters these two specimens conform to the type, and it is to be noted that even in the exopod of the third pleopods, the same parts are present on the last joint in both forms, *viz.*, two spines and a single ridged process on the inner lateral margin and a longer and a shorter spine at the apex. It is in the shape of the last two joints and the character of the two lateral spines that the two forms differ. Now the remaining seven males in this material are immature and the exopod of the third pleopods is of a form which will ultimately result in the form B of male pleopods, with further growth. It seems to me, therefore, that the two largest specimens of form B cannot be quite adult, in spite of their size compared with the size of form A and their mature look, and that the form B of male pleopods is a growth stage in the formation of the form A type. It cannot, I take it, be a case of "seasonal dimorphism" of the males (as for instance has been found by Wollebaek for the males of *Pandalus montagui*, in which the shape of the endoped of the first pleopods is of two forms, identified with the breeding and non-breeding seasons of the species) because forms A and B were found mixed together in the one bottle and therefore presumably captured together. It is possible that it is a case of definite dimorphism in the males but, if so, I cannot understand why the exopod of the third pleopods in the undoubtedly immature males should in all cases be of the form B type. A fourth explanation is possibly open, that we have here a case of high and low dimorphism among the males of this species, but the available data are insufficient to decide the question. I incline to the opinion that forms A and B are the final and penultimate stages in growth. It is unfortunate that the brush of setae on the antennules, which in most other Mysidae is well developed in adult males, should be feebly developed in *Gastrosaccus* so that this additional external mark of sexual maturity is not here available as a guide. Moreover the separation of species becomes more difficult because of the high systematic value hitherto set on the characters displayed by the pleopods of the male. At the same time, the form B of *G. muticus*, while resembling *G. simulans* more than form A in the shape of the exopod of the third pleopods of the male, offers no possibility of confusion with the latter because, apart from the differences in these appendages, the number of spines on the margins of the telson affords an additional distinguishing character.

Gastrosaccus simulans, sp. nov.

Locality.—Puri Beach, Orissa coast, washed up on shore, January, 1911, coll. F. H. Gravely, three adult females, 7-8 mm., one adult male, 7·5 mm., one imma-

ture female, 6·5 mm., and four newly hatched young. TYPES.—Regd. No. 8433/10, Ind. Mus.

Description.—This species is intermediate in its characters between *G. spinifer*, Goës, and the species described above, *G. muticus.* Like both these species it possesses a fringe of from six to eight slender spine-like filaments on the central dorsal posterior margin of the carapace and is therefore distinguished from every other described species of the genus.

In the three adult females and single adult male, there is no spine-like process on the fifth segment of the pleon. But in the single immature female and in all the newly-hatched young, this spine-like process is present, well developed and exactly as seen in adult specimens of *G. spinifer.* The inference is naturally that in the present species, the spine-like process is characteristic of the young and immature forms, and disappears with the attainment of sexual maturity. My material is too scanty to be definite on this point, but either my inference is the correct interpretation of the facts, or there are two closely allied species present in the gathering. I have judged of the maturity of my specimens by the state of development of the marsupial lamellae in the female and of the third pleopods of the male. It is certainly suggestive that the single female with the marsupial lamellae just appearing and the four newly-hatched young should all have the spine-like process well developed, while the obviously adult male and females should be without that process. The value of the presence or absence of this process as a specific character is likewise very much impaired if the above interpretation of the facts is the correct one. More material of the species is greatly to be desired to settle this point. In the character of the antennules, antennal scale, inner and outer uropods, and thoracic limbs, *G. simulans* agrees exactly with the description given for *G. muticus* above. The telson, however, has only from eight to ten spines on its lateral margins and is thus intermediate in this respect between *G. spinifer*, where the number is six to eight, and *G. muticus* with fourteen.

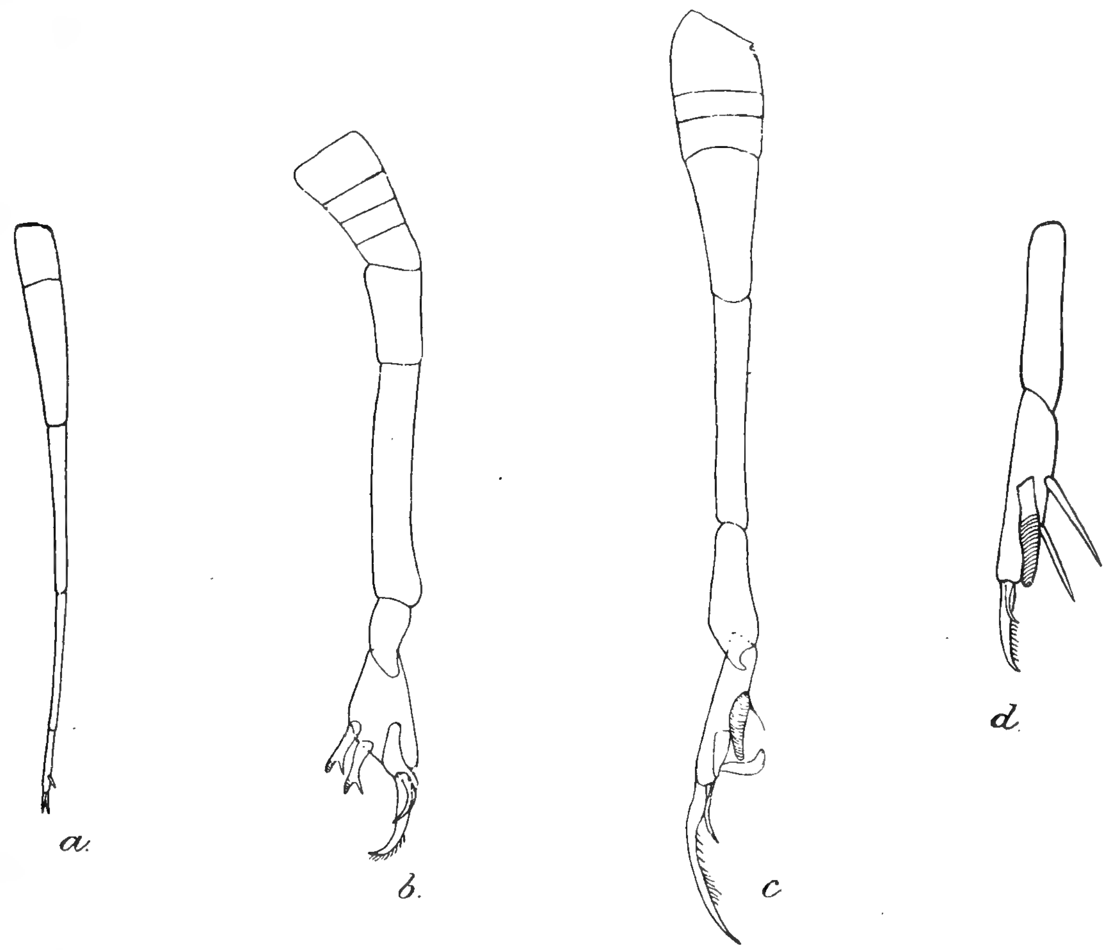
The pleopods of the male and female agree essentially with those described for *G. spinifer*, *G. sanctus* and *G. muticus*, except in the form of the exopod of the third pair in the male, and it is on the character of this appendage that I have relied for the institution of this new species.

The exopod of the third pair of pleopods of the male is elongate, reaching to the base of the telson. It is five-jointed, like the same appendage in both *G. muticus* and *G. spinifer*, but stouter than in the latter species, and perhaps slightly more slender than in the former. The first two joints are longer than the same joints in *G. muticus*, and combined are longer than the third joint instead of being equal to it as in *G. muticus.* The third joint is the longest and most slender. The fourth joint is markedly longer than in *G. muticus*, but has the lower distal margin produced into an obtuse lobe as in the latter species. The fifth joint is only slightly longer than the fourth, but more slender and not broadened out at its apex as in *G. muticus.* The apex of this joint bears a long slender curved spine minutely spinulated along the distal half of its inner margin. This spine is considerably longer than is the same

spine in *G. muticus* and bears at its base a similar shorter curved spine as in the latter species. The inner margin of the fifth joint bears two long obtusely-pointed and microscopically-ridged processes, but there are no signs of the prominent stout spines with the bifurcated tip so characteristic of *G. muticus.*

The length of adult male and females is 7-8 mm.

The following text-figures, showing the exopods of the third pleopod of the males of *G. spinifer*, *G. muticus* and *G. simulans*, will illustrate the fundamental differences in these organs in the three species and indicate the main characters on which the three forms are to be separated :—



TEXT-FIG. 1.—Exopod of third pleopod of male in three species of *Gastrosaccus*.
a. G. spinifer, Goës (× 25). *b. G. muticus*, n. sp. (× 60) Form A. *c. G. simulans*, n. sp. (× 60).
d. G. muticus, n. sp. (× 90) Form B.

I provisionally refer to this species, the specimens from the following locality :—

Estuary of the river Bassein, Burma, coll. Marine Survey of India, two adult females, 7 mm.

There are no adult males or immature specimens from the same locality, but these two females agree absolutely with the adult females of *G. simulans*, and I cannot see any reason for separating them at present.

The discovery of these two new species of *Gastrosaccus* illustrates, still further, the difficulty which exists in accurately discriminating the various species of the

genus. Hansen (1910 and 1912), who has in these publications instituted four new species of *Gastrosaccus*, frequently remarks on the close similarity between the females of the various species and the difficulty of separating them. As a result, however, of his researches on the genus he came to the conclusion that the character of the pleopods in the male afforded excellent specific characters and, following his lead, I have used these characters to separate the new species here described.

The genus now comprises the following twelve species :—

G. sanctus, van Beneden.
G. spinifer, Goës.
G. normani, G. O. Sars.
G. erythraeus, Kossman.
G. indicus, Hansen.
G. parvus, Hansen.
G. bengalensis, Hansen.
G. pacificus, Hansen.
G. vulgaris, Nakazawa.
G. kojimaensis, Nakazawa.
G. muticus, sp. nov.
G. simulans, sp. nov.

Of these twelve species, *G. spinifer* and the two species here instituted are immediately distinguished by the possession of a fringe of spine-like filaments on the central dorsal posterior margin of the carapace. The three species, *G. spinifer*, *G. muticus* and *G. simulans*, may be distinguished among themselves by the character of the exopod of the third pleopod of the male as shown in the text-figure and otherwise by the following characters :—

	G. spinifer.	*G. muticus.*	*G. simulans.*
Spine on fifth segment of the pleon.	Present at all sizes.	Absent.	Present in young, absent in adult.
Spines on the second joint of antennular peduncle.	3	3 or 4	4
Spines on lateral margin of telson	6-8	14	8-10
Spines on inner margin of inner uropod ..	9-11	4	4
Size of adult specimens	20 mm.	6-7 mm.	7-8 mm.

The species of the genus *Gastrosaccus* may be arranged in two groups, according to the structure of the pleopods of the male, as follows:—

I. Endopod of the third pair, either rudimentary or a simple unjointed lobe.—
G. indicus, *G. parvus*, *G. bengalensis*, *G. normani*, *G. pacificus*, *G. erythraeus*.

In this group the endopod, or both endopod and exopod of the second pair of pleopods in the male, are not normal in shape and more or less reduced.

II. Endopod of the third pair of pleopods in the male, normal in form and armature and multi-articulate.

G. spinifer, G. sanctus, G. muticus, G. simulans, G. kojimaensis (as far as can be gathered from Nakazawa's meagre description).

In this group the second pair of pleopods of the male has both the exopod and endopod of normal form and armature and multi-articulate.

Group I represents the old genus *Haplostylus* instituted by Kossmann for *G. normani* and later cancelled by Hansen (1910) and merged in the genus *Gastrosaccus.* Group II represents the old genus *Gastrosaccus. G. vulgaris* would seem to provide the connecting link, since, according to Nakazawa's figures, the endopod of the third pair of pleopods of the male is much reduced and only two-jointed, while the second pair of pleopods of the male have both the endopod and exopod normal in form and armature and multi-articulate.

From the point of view, therefore, of the pleopods of the male, *G. muticus* and *G. simulans* agree with *G. spinifer* and *G. sanctus* and are readily distinguished from all the Indo-pacific species except possibly *G. kojimaensis,* the description of which is somewhat meagre.

The specimens of *G. simulans*, obtained at Puri, were found at night at the water's edge on a sandy beach facing the open sea. Their presence was detected in the first instance owing to their brilliant luminosity, which was of a general nature.

Sub-family *MYSINAE.*

Genus **MACROPSIS,** G. O. Sars.

Macropsis orientalis, Tattersall.

M. orientalis, Tattersall, 1908, 1914.

Further records :—Chittagong, pond at N.E. end of the town near the river, January, 1913, coll. N. Annandale and S. W. Kemp. Abundant.

Chilka Lake, abundant everywhere.

Madras Harbour, 4-6 feet, October 1913, coll. N. Annandale. One.

Cochin backwater, near Ernakulam, September 1914, coll. F. H. Gravely. Fifty-eight.

The last two records indicate an extension of the known distribution of this species in the littoral of India, and it has now been found at a number of localities situated at the head of the Bay of Bengal and on both sides of the Indian peninsula. At Chittagong in the Gangetic Delta, and apparently at all suitable localities as far south as Vizagapatam on the east coast, it is enormously abundant. It ascends some at any rate of the larger rivers on this coast for a great distance, at least 40 miles above tidal influence; but has not as yet been found in any isolated body of water. In many places it occurs in water that is permanently fresh; but it also occurs in sea-water.

In the Chilka Lake it is found everywhere, but most abundantly in the main area,

where the specific gravity of the water does not exceed 1·0150. Its presence is particularly noticeable at places where rocks rise out of comparatively deep water and masses of dead weed find lodgment and probably afford it food. Decaying algae seem to be attractive to it, and when it is in their vicinity its stomach and alimentary canal are filled with an opaque white substance that renders it relatively conspicuous.

Macropsis orientalis swims in large shoals a short distance below the surface. Each shoal, at any rate in the neighbourhood of rocks, has its own "beat" to which the majority of its members confine their movements. As a rule each individual swims for the whole length of the "beat" and turns when it comes to the end of it, but sometimes single members of the swarm turn halfway and there seems to be a tendency for all to move in an elongated figure-of-eight. The "beat" is never more than a foot wide and may be from 3 to 6 ft. long. Its limits are determined to some extent by the limits of the shadows cast by the rocks, for the animals evidently avoid strong light. A few adventurers occasionally break from the shoal and swim out sideways from it, but they always return to their company after a short trip. Similar movements were noticed in specimens captive in an aquarium.

Near the rocks at Ganta Sila at the south end of the lake a small cetacean, *Orcealla brevirostris*, was noticed swimming backwards and forwards among shoals of *M. orientalis* with its mouth open and apparently feeding upon them. Unfortunately opportunity for a post mortem examination of the animal was lacking.

Uriya fishermen of the lake catch large numbers of this Mysid by straining water through a cloth. They mix them with turmeric, boil and dry the mass, and eat it with rice. They say it is "very sweet" and the dish is known by the name of *netha*; the animals are called *sridhar*.

Genus **POTAMOMYSIS**, Czerniavsky.

Potamomysis assimilis, Tattersall.

P. assimilis, Tattersall, 1908, 1914.

Further records:—Chittagong, pond at N.E. end of town, near the river, January 1913, coll. N. Annandale and S. W. Kemp. Common.
Chilka Lake, abundant everywhere.

The telson of this species is subject to a considerable amount of variation. In the Chilka Lake, the apex of the telson tends to be much narrower than in the types and to have fewer spines, in some specimens as few as seven, which are larger than in the type specimens and not arranged in series at all. The spines on the lateral margins may be as many as thirteen. This range in variation naturally gives the shape of the telson a vastly different appearance in separate individuals, but all stages of intermediates may be found. The amount of variation in the telson may possibly be correlated with the enormous range in density of the water in the lake at different times.

Neomysis vulgaris in Britain is subject to variations in the arrangement of the armature of the telson, which Norman suggests is influenced by the quantity of

sewage in the water in which it lives. However this may be, it is a brackish water form and must live in water which is liable to great changes in salinity at different times and seasons of the year.

Potamomysis assimilis, which has not as yet been found on the west coast of India, is, as a rule, less abundant than *Macropsis orientalis* with which it usually occurs; but in pools at Chittagong it was actually the commoner of the two. In the Chilka Lake it is as widely distributed as the preceding species and has similar habits. It does not, however, form such large shoals and usually remains nearer the bottom. At the head of Rambha Bay it was found in comparatively large numbers among weeds growing in a few inches of water.

I have recently received specimens of this species from Madras where Dr. Annandale collected it in the Ennur backwater, in water of specific gravity varying from 1·000 to 1·0045 (corrected). This record represents an extension of the known geographical distribution of the species, which probably extends at least all down the west coast of India in suitable localities.

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FAUNA OF THE CHILKA LAKE

MAMMALS, REPTILES AND BATRACHIANS.

By N. ANNANDALE, *D.Sc., F.A.S.B.*

CONTENTS.

MAMMALS, REPTILES AND BATRACHIANS.

By N. ANNANDALE.

Only eleven species were found in the Chilka Lake of aquatic vertebrates other than fish. A large proportion of these species are distinctly estuarine rather than marine or fluviatile, and the only limnic form is the mud turtle *Emyda granosa intermedia.* The sub-species of this Chelonian that occurs in the lake is a Peninsular rather than an Indo-Gangetic form, while the snake *Chersydrus granulatus*, though its geographical range is very extensive, does not occur, so far as I am aware, in the deltas of either the Ganges or the Indus. The sea-snake *Hydrophis obscurus* is, of course, like other members of its family, a marine animal, as is also the Cetacean *Orcaella brevirostris*; but both have established themselves in estuarine tracts, the latter, indeed, living in rivers hundreds of miles above tidal influence as well as in the sea.

MAMMALS.

The only mammals that have any claim to be included in the aquatic fauna of the Chilka Lake are, if we except the domestic buffalo,[1] the otter *Lutra macrodus* and the small Cetacean *Orcaella brevirostris.* We have to thank Mr. Oldfield Thomas[2] for confirming our identification of these species, both of which are common and have a fairly wide geographical range.

Order *CARNIVORA*.

Lutra macrodus, Gray.

1888. *Lutra ellioti*, Blanford, *Faun. Brit. Ind.*, *Mammalia* (pt. 1), p. 185, fig. 49.
1891. *Lutra macrodus*, *id.*, *ibid.* (pt. 2), p. 601.

An adult male was obtained at Barkul Point in March, 1914.

This otter is common in all parts of the lake at which rocks occur. It is presumably to it, and not to *L. vulgaris*, that McMaster's note quoted by Blanford on

[1] Herds of buffaloes, which are of less massive build and have less heavy horns than those reared in Bengal, often wade or swim far out into the lake; the island of Nalbano, which is submerged for a part of the year and lies more than a mile off the mainland, is covered in the dry season with their tracks.

[2] Mr. Thomas has also been kind enough to name a small collection of terrestrial mammals and bats made incidentally, mostly at Satpara, in the course of our survey. The following species were obtained at Satpara, *Felis viverrina*, Bennett; *Viverricula malaccensis*, Gmelin; *Mungos auropunctatus*, Hodgson, and *Lepus ruficaudatus*, Geoffroy. The bat *Scotophilus kuhli*, Leach, was found in large numbers in small caves among the rocks of the islands at the south end of the lake, while the allied species *S. wroughtoni*, Thomas, had taken possession of the bungalow on Barkuda. A pigmy shrew, *Pachyurus hodgsoni*, Blyth, was taken under dead stems of cacti and screw-pines lying at the edge of the lake at Barkul. Its stomach was full of the sandhoppers (Amphipoda Gammaridea) abundant in such positions.

p. 184 of his volume in the "Fauna" properly refers. This note describes the concerted action of six individuals in fishing. Otters were seen swimming at some distance from shore in Balugaon Bay, but they were more commonly observed among the rocks at Barkul Point. The specimen shot at this place had a number of ticks on its feet; these have been identified by Prof. G. H. F. Nuttall and Mr. C. Warburton as nymphs of a species of *Aponomma.*

The precise distribution of this otter is uncertain, but it probably occurs all over the Indian Peninsula.

Order *CETACEA.*

Orcaella brevirostris (Owen).

1878. *Orcella fluminalis* and *O. brevirostris*, Anderson, *Zool. Anat. Results Yunnan*, pp. 358-416, pls. xxv, figs. 4, 5, xxv*a*, xxvii, figs. 3, etc.

1891. *Orcella brevirostris* and *O. fluminalis*, Blanford, *Faun. Brit. Ind.*, *Mammalia* (pt. 2), pp. 578, 579, fig. 189.

1891. *Orcella brevirostris*, Oldfield Thomas, *Ann. Mus. Civ. Stor. Nat. Genova* (2) X (XXX), p. 947.

1912. *Orcella brevirostris*, Turner, *Marine Mamm. Anat. Mus. Edinburgh*, p. 109.

A large male was found in a decomposing condition on the shore of Kalidai Id. in February, 1914. There was no indication of the manner in which it had met its death and only the skeleton could be preserved.

O. brevirostris lives in the outer channel of the Chilka Lake at all times of the year, in fresh as well as in salt water. In this part of the lake-system it was usually seen in small parties of three or four. When the lake was full, these parties kept to the middle of the channel, but in March they hung round the fishermen fishing close inshore with small seine-nets, swimming within a few feet of the men and being apparently attracted by their shouts. At Satpara, individuals were frequently observed rolling over and over on a shelf of sand at the margin of the lake; the water was so shallow that it did not cover more than half their bodies, but the animals, though apparently abandoning themselves to play, slipped over into deeper water instantaneously on the slightest movement on shore. They seemed to be far more suspicious in this direction than of any danger from the water. Out in the channel they commonly follow boats, and we were told that there was a man living near Satpara who could call them up to his boat and spear them for the sake of their oil, which in Orissa, as in other parts of India, is regarded as a cure for rheumatism, applied externally.

In the main area of the lake their habits are somewhat different, probably on account of the different nature of the shore and of differences in the distribution of the food-supply. They seem to desert this area completely in the latter part of the rains and none were observed in it in August, September or October. They were seen, however, in July and November. Off Ganta Sila and Barkul Point they frequently swim up and down opposite some rock or groups of rocks and a single individual would often seem to reserve to itself, at any rate for some days at a time, a special beat. This was noted both in February and March and in July. The Cetacean

would often rush in straight towards the rocks, as if about to land upon them, and on one occasion we saw an individual strand itself on a flat shelf and remain for some seconds with its flippers and the forepart of its body practically out of the water. At other times it swam along more slowly with its mouth open and the upper part of its head exposed. In this case it was probably feeding on the shoals of small Crustacea (*Macropsis orientalis*, Tattersall) that swarm along the edge of the rocks.

Oldfield Thomas (*op. cit.*, 1891) has given good reason for regarding the Irrawaddy form of this genus (*O. fluminalis*, Anderson) as identical with the marine one and Anderson's statement that it does not occur in the lower reaches of the river seems to be based on insufficient evidence. The species is found in the Bay of Bengal, the Straits of Malacca, Borneo and the Gulf of Siam. It ascends the Irrawaddy for hundreds of miles and occurs in the Gangetic delta with *Platanista gangetica*, though it apparently does not penetrate very far inland on the west side of the Bay of Bengal.

REPTILES AND BATRACHIANS.

The following is a list of the reptiles and batrachians found in the Chilka Lake:—

Reptilia.

OPHIDIA.
- *Chersydrus granulatus.*
- *Cerberus rhynchops.*
- *Hydrophis obscurus.*

EMYDOSAURIA.
- *Crocodilus palustris.*
- *Gavialis gangeticus.*

CHELONIA.
- *Chelone imbricata.*
- *Chelone mydas.*
- *Emyda granosa intermedia.*

Batrachia.

Rana cyanophlyctis.

The three snakes all belong to the family Colubridae, but to three different groups of that great assemblage: *Chersydrus granulatus* to the Aglypha, *Cerberus rhynchops* to the Opisthoglypha and *Hydrophis obscurus* to the Proteroglypha. As all three are modified to a greater or less extent—*Cerberus* less than the others—for an aquatic existence, and as the modifications are the same or tend in the same direction, the species afford an interesting instance of convergence.

From a geographical point of view the three snakes have some interest. *Chersydrus granulatus*, which is a true estuarine species sometimes found out at sea, is widely distributed in the Malay Archipelago, but in Indian waters is apparently restricted to the east coast of the Peninsular Area and the southern part of the Malabar Zone. *Cerberus rhynchops*, which ascends rivers far higher than the limits of their estuaries, has a similar general distribution, but is found in the Gangetic and other Indian river-systems beyond the range of *Chersydrus*. *Hydrophis obscurus* is, so far

as we know, an exclusively Indian and Burmese snake, occurring on both sides of the Peninsula and on the coast of Tenasserim. It particularly affects brackish water and occurs in the Gangetic delta.

Thus we may say that the snakes of the Chilka Lake represent an essentially estuarine element in its fauna and one of wide, or fairly wide, dispersion in the Oriental Region.

Crocodilus palustris has a range similar to but even wider than that of *Cerberus rhynchops*, and is more of an up-country animal. *Gavialis gangeticus*, on the other hand, is entirely confined on the east coast of India to river-systems that open into the upper part of the Bay of Bengal; it is probably not found, even on this coast, further south than the Chilka Lake. On the western side of India it occurs, like *Orcaella brevirostris*, in the Indus.

Of the Chelonia of the lake the two Chelonidae are widely-distributed marine species, while the Trionychid is an essentially limnic form somewhat restricted in range —a local race, confined to the river-systems of the Mahanaddi and the Godavari and a few adjacent valleys, of a species that occurs all over Peninsular India, the Indo-Gangetic plain, the greater part of Burma and the plains of Ceylon. Its genus, which is monotypic, is not found, except in Ceylon, beyond the limits of the Indian Empire.

Rana cyanophlyctis, the only frog or toad found in the lake, occurs over an area extending from Arabia to the Malay Peninsula, and is known to avoid brackish water less than most of its congeners.

Considered as a whole, the herpetological fauna of the Chilka Lake may therefore be regarded as an essentially estuarine one, in which most of the species are of wide distribution; there is no endemic element. In so far as it is peculiarly Indian, it is, as might be expected, Peninsular as opposed to Indo-Gangetic.[1]

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[1] A word may be said as to the terrestrial reptiles and frogs that haunt the margins of the Chilka Lake. The most conspicuous is the Indian Monitor (*Varanus bengalensis*), which was seen on several occasions on the stony beach of Barkuda Island, but is much more often to be observed, in Orissa and Ganjam, in holes in the walls of wells or among the trunks of fallen trees. It does not wander over the mud-flats, as *V. salvator* and *V. nebulosus* do in some parts of the Malay Peninsula, and probably obtains little if any of its food from the lake. A small skink (*Lygosoma punctatum*) was found under dead Pandanus-leaves at the edge of the lake near Barkul. Its stomach contained amphipodous crustacea of the group Gammaridea. The same animals are eaten by two species of Gecko (*Hemidactylus brookei* and *H. frenatus*) that are abundant among stones and rocks just above the water-level and occur even on the smallest islands in the lake. They also feed largely on the Saldid bug *Leptopus assuanensis*, which, without being exactly aquatic or even amphibious, is extremely abundant round the lake among rocks and stones in the immediate neighbourhood of water. The four lizards all have a wide range in the plains of India.

Two burrowing frogs (*Rana breviceps* and *Microhyla ornata*) live commonly in holes near the edge of the lake and breed in the rainy season in small pools of rain-water close to the margin; but we have never seen them enter the lake itself. At Barkul, one night in September, we saw a young Chunam Frog (*Rhacophorus maculatus*) seated on dead weed at the margin. All these are common frogs in the plains of Peninsular India and the Indo-Gangetic tract.

OPHIDIA.

Family COLUBRIDAE.

Subfamily *ACROCHORDINAE*.

Genus **Chersydrus**, Cuvier.

1890. *Chersydrus*, Boulenger, *Faun. Brit. Ind., Rept.*, p. 355.
1912. ,, Barbour, *Mem. Mus. Comp. Zool. Harvard*, XLIV, No. 1, p. 106.

Barbour (1912) doubts whether this genus is really distinct from the type-genus of the subfamily *Acrochordus*, Hornstedt. His doubts are probably well founded, but I have no specimens of *Acrochordus* for comparison; the only species (*A. javanicus*) occurs in fresh water in the Malay Peninsula and Archipelago.

Chersydrus granulatus (Schneider).

1890. *Chersydrus granulatus*, Boulenger, *Faun. Brit. Ind., Rept.*, p. 355, fig. 104.
1912. ,, ,, *id.*, *Faun. Malay Peninsula, Rept.*, p. 116, fig. 38.
1912. ,, ,, Barbour, *Mem. Mus. Comp. Zool. Harvard*, XLIV, No. 1, p. 106.
1914. ,, ,, Wall, *Journ. Bombay Nat. Hist. Soc.* XXIII, p. 372.

Barbour (1912) has noted the more conspicuous colouration in the young of this snake, a common feature of young reptiles,[1] and also the increased stoutness of the adult. Wall has recently (1914) put on record a Siamese specimen 4 ft. 4 inches long and with a maximum girth of $7\frac{1}{4}$ inches, presumably in spirit.

The range of the species extends from the Malabar coast to New Guinea, but apparently omits the Gangetic delta and fails to extend far up the west coast of the Indian Peninsula. It is common in estuaries and backwaters on the east coast and is sometimes found at sea. In the Chilka Lake it is not restricted to any particular locality.

C. granulatus may often be seen thrusting its head from the surface of the lake, where it is usually found some little distance from shore. On land it is sluggish and unable to progress rapidly; probably it never leaves the water unless forced to do so. Barbour found it abundant in the fish-market at Macassar, under platforms on which the fish were sold, but thought it probable that it had been introduced accidentally into such positions. It was taken in our trawl on several occasions and probably often rests on the mud at the bottom. Fishermen frequently brought it to us at Rambha, Barkul and elsewhere. Some of them distinguished it from *Hydrophis* as not being poisonous. No large specimens were obtained.

Subfamily *HOMALOPSINAE*.

Genus **Cerberus**, Cuvier.

1890. *Cerberus*, Boulenger, *Faun. Brit. Ind., Rept.*, p. 374.
1907. *Hurria*, Stejneger, *Bull. U.S. Nat. Mus.* LVIII, p. 307.

Stejneger has revived the long obsolete name *Hurria* for this genus. In the strict letter of the law of priority he may be right, but the change is not adopted by Boulenger in his volume on the Fauna of the Malay Peninsula (1912).

[1] See Annandale in Boulenger's "Report on the Batrachians and Reptiles", *Fasciculi Malayenses* (*Zool.*) I, p. 156.

Cerberus rhynchops (Schneider).

1912. *Hurria rhynchops*, Barbour, *Mem. Mus. Comp. Zool. Harvard*, XLIV, No. 1, p. 123.

This species has an even wider range than *Chersydrus granulatus*, for it occurs in all the Indian rivers and estuaries and throughout the Malay Archipelago as far as New Guinea. In the extreme east of its range it is, however, scarce.

Less exclusively aquatic in its habits than *Chersydrus*, it probably never goes far from water. In estuarine tracts it is particularly abundant, but it also makes its way far up rivers. In the Gangetic delta it is one of the commonest snakes in suitable localities, that is to say in ditches, creeks and swamps of brackish water, in which it either lies at the bottom or remains concealed among vegetation at the edge. It also frequents the deep cracks formed in mud exposed to the heat of the sun at low tide. I have watched it, from a stranded boat, emerging from those cracks below water as the tide covered them. Round the Chilka Lake it lies under the felted algae left at the edge as the water-level sinks in the dry season, and also conceals itself among submerged stones on islands such as Kalidai and Barkuda. Its habits render it less liable to be caught in fishermens' nets than either of the other snakes of the lake, for it rarely swims in the open. On land it is less awkward than *Chersydrus*.

The type-specimen of Schneider's *Hydrus rhynchops* was from the Ganjam district.

Subfamily *HYDROPHIDINAE*.

Genus **Hydrophis**, Daudin.

1890. *Hydrophis* and *Distira*, Boulenger, *Faun. Brit. Ind., Rept.*, pp. 398, 407.
1909. *Distira*, Wall, *Mem. Asiat. Soc. Bengal*, II, p. 193.
1912. *Hydrophis*, Boulenger, *Faun. Malay Peninsula, Rept.*, p. 181.

Boulenger has recently accepted the view that the two genera *Distira* and *Hydrophis* cannot be separated. The former was described one year later than the latter.

Hydrophis obscurus, Daudin.

1890. *Hydrophis coronatus*, Boulenger, *Faun. Brit. Ind., Rept.*, p. 402.
1909. *Distira obscura*, Wall, *Mem. Asiat. Soc. Bengal*, II, p. 201.
1912. *Hydrophis obscurus*, Boulenger, *Faun. Malay Peninsula, Rept.*, p. 188.
1914. *Hydrophis coronatus*, Wall, *Journ. Bombay Nat. Hist. Soc.* XXII, p. 374.

There has been considerable confusion in the synonomy of this species. Wall set the matter right, so far as the specific name was concerned, in 1909 and is followed in this respect by Boulenger. Unfortunately the former author has revived the name *coronatus* in a recent note (1914), but without giving reasons. This name was applied by Günther in his *Reptiles of British India* (1864) to the young snake, of which he gives an excellent figure (pl. xxv, fig. M., *op. cit.*), and is more than half a century younger than Daudin's "*obscurus*", which is wrongly applied by Boulenger, as he himself has pointed out (1912), in the "Fauna" and the British Museum *Catalogue of Snakes*.

In scaling and proportions *H. obscurus* is more constant than most sea-snakes, but, like many other reptiles, it is more conspicuously coloured when young than when fully mature. In the young the pale bands and the markings on the head are bright yellow, which contrasts brilliantly with the blue-black of the ground-colour. In older individuals the contrast is much less striking, for the yellow fades to dirty white and the black to grey. On the hinder parts, indeed, all markings completely disappear. The largest specimen I have seen, a male killed at Satpara, was (when fresh) 122 cm. long.

This snake is mainly but not exclusively an inhabitant of brackish water. It occurs at least up to the limits of tidal influence in the Gangetic delta and is common all over the Chilka Lake. It has also been recorded from the coasts of Madras and Tenasserim and from Karwar in the Bombay Presidency. The last seems to be the only locality outside the Bay of Bengal whence it has been reported.

In the Chilka Lake it frequents both open water and the margin, where the latter is low and weedy. We saw it on several occasions thrusting its head and the forepart of its body vertically upwards out of the water, and specimens captured in seine-nets, sometimes with *Chersydrus granulatus*, were brought to us at Rambha, Barkul and Satpara. Like other true sea-snakes, and also like *Chersydrus* and *Cerberus*, it feeds on fish. It does not hesitate to swallow even *Triacanthus brevirostris*, which has a pair of long and stout spines that can be thrust out from the sides of the belly and firmly locked in position in such a way that they cannot be bent back without being broken. It sometimes happens that when the snake has swallowed a fish of this kind, the spines of the latter become locked in its stomach and pierce both the walls of the alimentary canal and those of the body. I have seen, both in Orissa and on the coast of the Malay Peninsula, sea-snakes with these spines protruding through the skin. Apparently digestion proceeds normally in these abnormal circumstances and the fish is disintegrated in the process. The spines are then set free and fall out from the body of the snake, which seems to be little the worse for the perforation.

H. obscurus, probably because of its frequenting brackish water, is apparently free from the hydroids and barnacles (*Dichelaspis grayi* and other species) that often attach themselves to other sea-snakes of the same and other genera; we did not find any parasites in its internal organs.

EMYDOSAURIA.

Genus **Crocodilus**, Laur.

Only the smaller of the two Indian crocodiles was seen in the lake in circumstances that made identification possible, and we obtained no evidence as to the occurrence of *C. porosus*.

Crocodilus palustris, Lesson.

The short-nosed crocodile is common near Barkuda and Cherriakuda, on the sandy parts of the shores of which we occasionally saw it. Our *serang* told us that

he had seen young[1] on the latter island. The individuals that frequent these places are, however, extraordinarily timid and rarely leave the water for more than short periods. As a rule they lie in it at the edge. The fishermen do not seem to be much afraid of them. At Satpara we saw men, women and children bathing in a tank within a few yards of a couple of crocodiles which were floating on the surface, the larger being 6 to 8 ft. long. They said that the crocodiles only eat fish. Generally speaking, these animals, though they do not avoid village tanks, seem to be confined in the lake to those parts that are low and have sloping shores and are at the same time remote from human habitations. Possibly they fear the formidable fish-spears carried in the fishing boats.

Genus **Gavialis**, Günther.

1864. *Gavialis*, Günther, *Rept. Brit. Ind.*, p. 63.
1876. *Gharialis*, Theobald, *Cat. Rept. Ind.*, p. 37.

The name *Gavialis* is a latinized form of a misreading of the Hindustani "gharial", just as the name *dugong* is a misreading of the Malay *duyong*; but Theobald's emendation has not been accepted by most recent herpetologists.

Gavialis gangeticus (Gmelin).

We were informed on good authority that this species occurs in the lake in the neighbourhood of Satpara, and on less good authority that one is known to the fishermen to frequent Kalidai Id. If the information is correct, this must be practically the southern limit of the range of the species and genus, which is not known further down the coast of India than the Mahanaddi river-system. It is found in all the rivers that flow into the head of the Bay of Bengal, including the Koladyne in Arrakan, but not in the Irrawaddy. Like the mud-turtle *Trionyx gangeticus* and the porpoise *Platanista gangetica*, it occurs in the Indus as well as in the east coast systems.

CHELONIA.

Family CHELONIDAE.

The two species of this family here recorded from the outer channel of the Chilka Lake are probably mere casual visitors. Very possibly the third Indian species, *Thalassochelys caretta*, also enters the sea-mouth occasionally. We obtained no evidence as to any turtle breeding on the shores of either the outer channel or the main area of the lake, and it is only those of the former that would be at all suitable for the purpose.

Genus **Chelone**, Brougniart.

Chelone imbricata (Linn.)

A large shell of the Tortoiseshell Turtle was seen on the shore of Barhampur Id. in the outer channel in March, 1914.

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[1] An interesting account of the nest of this crocodile has recently been published by W. Schultze in the *Philippine Journ. Sci.* (D) IX, pp. 313-315, pl. i (1914).

Chelone mydas (Linn.).

A male of this species was taken in the otter-trawl in fresh water in the inner part of the outer channel (Sept., 1914). Its carapace was 102 cm. long. The stomach and the entire intestinal tract were tightly packed with weed. No external or internal parasites were found on or in the specimen.

Family TRIONYCHIDAE.

Genus **Emyda**, Gray.

This genus is monotypic but the single species is divided into five subspecies or local races:—the *forma typica,* which occupies the Indo-Gangetic plain and ranges eastwards to Arrakan; *scutata,* which occurs in the Irrawaddy and Salween systems; *intermedia,* practically confined to the Mahanaddi and Godavari systems; *vittata,* widely distributed over the remainder of Peninsular India and in Katch; *ceylonensis,* only found in the plains of Ceylon.

Emyda granosa (Schoepff) subsp. **intermedia**, Annandale.

1912. *Emyda granosa intermedia*, Annandale, *Rec. Ind. Mus.*, VII, p. 172, pl. vi, fig. 2.

The races of *E. granosa* as a rule occur only in fresh water, but the typical form has been taken on a small island off the coast of Arrakan. The Mahanaddi Pond Turtle, as the race *intermedia* may be called, is common in ponds all over the Mahanaddi system and at any rate on the lower reaches of the Godavari. It also occurs in the valleys of some of the smaller rivers that make their way from the south or south-west into the estuary of the Hughli, although in the Hughli itself the subspecies is the *forma typica.* In the neighbourhood of the Chilka Lake *intermedia* is common in ponds and rice-fields. A specimen was brought to us at Barkul in September that had been found under a stone in the jungle some distance from water. In the thickets of submerged weeds in the lake near Balugaon it is not uncommon. Specimens were obtained both in September, when the water was quite fresh, and in March, when its specific gravity (at 15° C.) was 1·008. It is somewhat remarkable to find a soft-skinned Chelonian living in brackish water, but the sole species of an allied Indian and Malayan genus (*Pelochelys cantoris* [1]) is exclusively estuarine and marine.

A leech was found infesting the soft parts of the pond-turtle in the lake in March. It has been identified by Mr. W. A. Harding as a new species of *Placobdella.*

BATRACHIA.

The only batrachian that we saw in the lake was the common and widely distributed frog *Rana cyanophlyctis,* Schneider. In the rainy season and for as long thereafter as the water remains fairly fresh, this frog sits in large numbers at the edge both of the outer channel and of the northern part of the main area, at places where the margin is swampy, and skips over the surface of the water in its characteristic fashion

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[1] See Boulenger, *Faun. Malay Peninsula, Rept.*, p. 12 (1912.)

when alarmed.[1] We obtained no evidence, however, that it ever breeds in the lake. Its tadpoles were observed, with those of *R. breviceps* and *Microhyla ornata*, in pools of rain-water on the banks in September.

[1] *Ibid.*, p. 229 (1912).

FAUNA OF THE CHILKA LAKE

AQUATIC INSECTS, OTHER THAN COLEOPTERA, WITH NOTES ON SOME MARGINAL SPECIES.

By N. ANNANDALE, *D.Sc.*, *and* STANLEY KEMP, *B.A.*
ODONATA by F. F. LAIDLAW, *F.Z.S.*

(Plate XI.)

CONTENTS.

AQUATIC AND MARGINAL INSECTS.

By N. ANNANDALE *and* STANLEY KEMP.

In the case of the insects it is particularly difficult to draw a line between aquatic and terrestrial species. Strictly speaking, indeed, all those that occur in water or on its surface should be called amphibious rather than either aquatic or terrestrial, for all insects, at any rate in adult life, are air-breathing animals. Moreover, though many species and larger groups are specialized for peculiar modes of life, the class as a whole is remarkably tolerant and not easily deterred from occupying all situations available. In considering the fauna of any body of water, the doubtful status of a number of insects that can hardly be rejected as terrestrial animals or claimed as true aquatic species must, therefore, be decided—the status, that is to say, of forms that frequent the damp margins, concealing themselves under stones and jetsam, burrowing in sand or mud, or crawling on damp rocks. Some of these species are essentially moisture-loving terrestrial forms, found also in other situations, while a few occur only at the edges of rivers, lakes, ponds or lagoons.

In discussing the insect fauna of the Chilka Lake we have found it convenient for this reason to devote a section of our paper to "marginal" species, in addition to annotating the insects that may legitimately be called aquatic. We are indebted to Mr. F. F. Laïdlaw for an account of the only dragon-fly that breeds habitually[1] in the lake.

I. AQUATIC INSECTS.

Apart from Coleoptera,[2] which we are unable to consider at present, the aquatic insects of the Chilka Lake include at least twenty species, the majority of which (15 species) belong to the order Rhynchota. Only a very small minority of these insects can be regarded as anything but casual visitors. Except for a moth, a dragon-fly and three Diptera, the only species that we know to complete its metamorphosis in the lake is the Hydrometrid bug *Euratas formidabilis*, and it is quite clear that all the former deposit their eggs indifferently either on the surface of the lake or on any other body of water they may chance to encounter in their flight.

There are thus only six forms that we know to breed in the Chilka Lake; particulars of these species are given in the following table :—

[1] We found cast nymphal skins of two other species, an Aeschnid, probably *Anax guttatus* (Burm.), and a Libellulid, adhering to rocks at the edge of the lake, but the species of these families that are often seen flying over its surface usually breed elsewhere.

[2] About six species of Dytiscidae, ten of Hydrophilidae and one of Gyrinidae are found in the lake.

	Breeds in water of sp. gr.	General distribution.
Odonata		
Pseudagrion microcephalum ..	1·001—1·008	India and Malaysia.
Rhynchota		
Euratas formidabilis	1·000—1·0265	Bay of Bengal.
Diptera		
Eristalis arvorum	1·0035—1·007	Oriental region.
Palpomyia sp	1·008	
Anopheles rossii	1·000—1·015	Tropical and subtropical countries.
Lepidoptera		
Nymphula diminutalis	1·008	Northern India to Celebes.

Unlike the other groups of animals with which we have to deal in this volume, the insects are for the most part immigrants from fresh water and drift or fly into or on to the lake from the neighbouring ponds or rice-fields. *Euratas formidabilis* is possibly the only exception, belonging to a marine group and having been taken at sea in the neighbourhood of land.

A phenomenon that exercises considerable influence on immigration in the case of both surface-living and sub-aquatic species is the periodic growth and decay of a weed of the genus *Potamogeton* that forms dense submerged thickets during the dry season in certain sheltered bays of the main area of the lake, dying down almost completely in the "rains." The dry season is also the season at which the water of the lake has the highest specific gravity, that is to say, is saltest; but increase of salinity seems to be of less importance than the existence of adequate shelter. The only situation in which we found insect life at all vigorous was in thickets of this weed, in water of specific gravity varying from 1·001 to 1·008. Both submerged and surface forms were abundant in or over the weed, the latter including *Hebrus bengalensis*, *Mesovelia mulsanti*, *Hydrometra vittata* and several species of *Gerris* among the Rhynchota, the former *Micronecta proba*, and *Sphaerodema rusticum* of the same order, as well as a number of small beetles of the families Dytiscidae and Hydrophilidae, the larvae and pupae of the flies *Anopheles rossii* and *Palpomyia* sp., of the moth *Nymphula diminutalis* and of the dragon-fly *Pseudagrion microcephalum*.

The great majority of the aquatic insects of the lake are species of very wide distribution in the Oriental region, if they do not even extend beyond its borders.

Order *ODONATA*.

By F. F. LAIDLAW.

Family **Agrionidae**.

Pseudagrion microcephalum (Ramb.).

1890. *Pseudagrion microcephalum*, Kirby, *Cat. Odonata*, p. 153.
1900. ,, ,, Ris, *Arch. Naturgesch.*, p. 198.
1902. ,, ,, Laidlaw, *Proc. Zool. Soc. London*, p. 388.
1904. ,, ,, Martin, *Mission Pavie*, p. 18 (sep)

Adult specimens have been examined from off Balugaon and Barkul on the Chilka Lake; the majority were taken in March, but I understand that the species is common at all times of the year. Others are from Balighai on the Sar Lake in the Puri district of Orissa and from Calcutta. Larvae and larval exuviae were sent both from the Chilka Lake and from the Museum tank, Calcutta, in several cases with adults which had been reared in an aquarium.

The species is evidently very abundant in Bengal and Orissa. I believe it to be the true *P. microcephalum* of Rambur. To facilitate identification I have figured the terminal part of the abdomen of the male, as seen from above, and also the colour pattern of the dorsum of the second abdominal segment of the same sex (text-figs. 1A, B). The superior anal appendages of the male are about equal in length to the tenth segment, whereas in the closely allied *P. australasiae* the corresponding appendages are not more than one-half the length of the segment, and differ in shape.

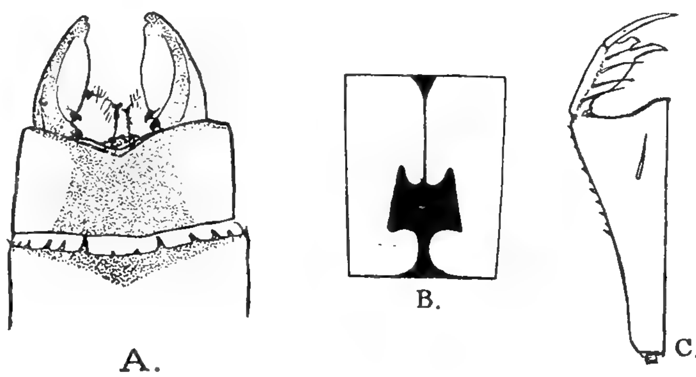

FIG. 1.—*Pseudagrion microcephalum* (Ramb.).
A. Apex of abdomen of male, from above.
B. Pattern on dorsum of 2nd abdominal segment of male.
C. " Mask " of larva.

The colouring of young males of *P. microcephalum* is identical with that of the females.

Larva.—Very similar in general to that of European *Erythromma najas* (Hausemann). Body slender, of a pale sandy gray colour.

Total length at time of emergence about 22 mm., of this the caudal lamellae take up about 8 mm.

Head pentagonal, antennae 7-jointed. Mask long (text-fig. 1C), its anterior border gently rounded, extending when folded beyond the insertion of the second pair of legs. Its outer margin carries a few small spines, and there is a single large seta on either side of the body. The palpi bear four stout setae directed inwards and the movable hooks are long and overlap (text-fig. 1C).

The caudal lamellae have nearly parallel sides and are bluntly rounded at their apices. Each is divided into two parts at about its middle by a transverse fold or joint. Of these two parts the proximal has its margins spiny and there is a distinct notch on the lower margin (of the lateral lamellae) between the proximal and distal parts. The last spine on either margin before the transverse fold is the largest of the series. The apical part has its margins smooth.

There are two main tracheal trunks in each lamella. These cross and recross one another; their branches are arborescent near the margins and are marked with a dark brown colour giving the lamella a mottled appearance.

The larvae from Lake Chilka were collected in water which was distinctly brackish, the specific gravity (corrected) of the water being 1·008. I believe no Agrionid larva has been recorded from brackish or salt water. Amongst the Libellulinae

Dr. Ris suspects that the larval forms of the two species of *Macrodiplax* may inhabit salt water (Muttkowski, *Bull. Publ. Mus. Milwaukee*, I, p. 183 note). I can detect no differences between the examples from Lake Chilka and those from Calcutta which were taken in pure fresh water.

In addition to *Pseudagrion microcephalum*, I have received specimens of the following species collected by Dr. Annandale and Mr. Kemp in the neighbourhood of the lake.

AGRIONINAE.

Ceriagrion coromandelianum (Fabr.): Barkuda Id., 2 ♂ ♂, 1 ♀.

"Abdomen gamboge yellow, brownish at tip. Legs and face paler; dorsal surface, side of thorax and head, including eyes, emerald green. Ventral surface of thorax whitish."

Ischnura senegalensis, Ramb.: common; probably breeds in the lake.

LIBELLULINAE.

Potamarcha obscura (Ramb.): Satpara, 16-ix-13, 1 ♀; Barkuda Id., 17-vii-14, 1 ♂.

Brachydiplax sobrina (Ramb.): Barkuda Id., 17-vii-14, 2 ♂ ♂.

Diplacodes trivialis (Ramb.): Barkuda Id., 17-vii-14, 3 ♂ ♂; Cherria Id., 1 ♀; Patsahanipur, i-14, 1 ♂, 1 ♀.

Crocothemis servilia (Drury): Barkuda Id., 17-vii-14, 1 ♂, 1 ♀. The male has a deformed wing, with abnormal venation; I hope subsequently to figure the specimen.

Pantala flavescens (Fabr.): Barkuda Id., 18–19-vii-14, 2 ♂ ♂, 2 ♀ ♀.

With the possible exception of *Brachydiplax sobrina* all the species are exactly the forms one would expect to meet with in such a locality as the shores of Lake Chilka. In addition I have just received from Dr. Annandale the cast skin of a nymph belonging in all probability to *Anax guttatus* (Burm.). I have not access to Cabot's account of the larval stages of the Aeschninae at the present moment, but I have little doubt but that the identification is correct; the specimen agrees substantially with Needham's description and figure[1] of a nymph from Buitenzorg which he regards as belonging to Burmeister's species. The skin was "found on a rock at the edge (of the lake) near Patsahanipur" and Annandale remarks that the dragon-fly must breed in the lake. This view is further supported by the fact that the skin has attached to it some six very small shells, evidently the young of a species of *Modiola* very likely *M. striatula*, Hanley.

Lastly, the series includes two females of a species of *Agriocnemis* taken at Barkuda Id., 17-vii-14,—another genus likely to be represented in coastwise country.

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[1] *Proc. U. S. Nat. Mus.*, XXVII, p. 695, pl. xl, fig. 2 (1904).

Order *RHYNCHOTA*.

The aquatic Rhynchotal fauna of the lake comprises fifteen species, representing eleven genera and six families. The majority (8 species, 5 genera) belong to the Hydrometridae; there are three species (2 genera) of Corixidae, while the Hebridae, Nepidae, Belostomatidae and Notonectidae have each a single species.

The aquatic species of this order, to judge from the large number described in Distant's supplement (vol. V, 1910) to his account of the Rhynchota in the *Fauna of British India*, are still imperfectly known so far as the Oriental region is concerned. It is therefore noteworthy that there is only one species in our collection from the Chilka Lake that we have not been able to identify. It is a small apterous Hydrometrid belonging to the subfamily Veliinae and bearing some resemblance to *Rhagovelia nigricans* (Burmeister); but as we have only a single specimen, which is probably immature, we refrain from discussing the species further.

Euratas formidabilis is the only species which we believe to undergo its full metamorphosis in, or rather on, the lake; the only other form of which we found an immature stage was a *Gerris*, probably *G. spinolae*, of which a single larva was obtained.

Descriptions of all the species here discussed will be found in Distant's volumes in the *Fauna of British India and Ceylon*, the volumes in which aquatic families are described being II (1904), III (1906) and V (1910); our references are to this work. The only form on which we have any remarks to offer as to structure or systematic position is *Euratas formidabilis* (see p. 183).

Family **Hebridae.**

Hebrus bengalensis, Distant, vol. V, p. 132, fig. 70.

Mr. Distant has been kind enough to identify specimens of this species. It is not uncommon among rocks and on wet sand at the edge of the lake, occurring both in the main area and in the outer channel at all times of the year. Its original locality is recorded as Lower Bengal.

Family **Hydrometridae.**

Hydrometra vittata, Ståhl, Distant, vol. II, p. 170, fig. 23 and vol. V, p. 137.

H. vittata is common on the surface of the main area of the lake in winter months, occurring chiefly on thickets of *Potamogeton*. It is a common species all over India and has also been found in the Malay Archipelago and Japan. In the Gangetic delta it often occurs on pools of brackish water.

Mesovelia mulsanti, Buch. White, Distant, vol. II, p. 169, fig. 122.

Another common species found over weeds and also among rocks in the main area of the lake, chiefly in the winter months. It probably occurs all over the Oriental region and has been found also in North and Central America and in the Antilles.

Gerris nitida (Mayr), Distant, vol. II, p. 178 and vol. V, p. 142.

A few specimens of this pond-skater were taken among rocks at the edge of the lake at Ganta Sila in December. It is widely distributed in India, Burma and Ceylon, ascending the Himalayas to an altitude of at least 7000 ft.

Gerris fossarum (Fabricius), Distant, vol. II, p. 178 and vol. V, p. 142.

Specimens were taken at Ganta Sila in winter and at Nalbano in the "rains." The species is common on pools of brackish water in the Gangetic delta and has a wide range in the Oriental region and Australia. It occurs in the Darjiling district at an altitude of 7000 ft.

Gerris tristan, Kirkaldy, Distant, vol. II, p. 179 and vol. V, p. 144.

A few specimens were obtained at Nalbano, Barkul and Ganta Sila in September and December. The species was described from Ceylon and has since been recorded from various localities in India and Burma. It is common on brackish water in the Gangetic delta.

Gerris spinolae, Leth. and Serv., Distant, vol. II, p. 180.

G. spinolae is occasionally found near the inner shore of the main area of the lake in winter; in the "rains" it enters this area in considerable numbers from ditches and flooded rice-fields, in which it is very abundant. The species occurs in many parts of India, Burma and Ceylon, and also in China.

Euratas formidabilis, Distant (see p. 183, *postea*).

Family **Nepidae.**

Ranatra sordidula, Dohrn, Distant, vol. III, p. 22.

A single specimen was taken at Ganta Sila in December. The species is widely distributed in India and neighbouring countries.

Family **Belostomatidae.**

Sphaerodema rusticum (Fabricius), Distant, vol. III, p. 36, fig. 23.

The species is found among weeds in the main area of the lake in the dry season. It is common in India and the surrounding countries.

Family **Notonectidae.**

Anisops ? breddini, Kirkaldy, Distant, vol. V, p. 333, fig. 194.

There is some doubt as to the identity of the Indian species; our specimens from the Chilka Lake agree well with the one figured by Distant. They were taken at the northern end of the main area of the lake in the freshwater season, the only time at which we saw any Notonectid in the lake. The same species is, however, abundant in pools of brackish water at Port Canning in the Gangetic delta, as well as in fresh water at Calcutta. *A. breddini* was described, very imperfectly, from Madagascar.

Family **Corixidae.**

Corixa substriata, Uhle, Distant, vol. V, p. 340.

A single specimen, which apparently belongs to this species, was taken off Barkul Point in March. The species occurs both in the plains and hills of India, in Ceylon and also in Japan.

Micronecta minthe, Distant, vol. V, p. 347, fig. 208.

This species is common in the main area of the lake in the freshwater season and also occurs in the same season near Manikpatna in the outer channel, where it was found among vegetation submerged by the monsoon floods. *M. minthe* was originally described from a number of localities in the plains of India and Ceylon.

Micronecta proba, Distant, vol. V, p. 348, fig. 210.

M. proba was common among water-weeds in Balugaon Bay in March. It was described from the plains of Northern India and Upper Burma.

NOTE ON THE GENUS *EURATAS*, DISTANT.

The genus *Euratas* was described by Distant (vol. V, p. 154) from specimens long immersed in alcohol and then dried; they were obtained in the Andaman Sea. From the same collection and locality he also described (*loc. cit.*, p. 155) a second supposed genus, *Fabatus*, which, as he himself acknowledged, was based on immature specimens. An examination of co-types of both genera and also of much fresh material has convinced us that *Fabatus* is merely a nymphal stage of *Euratas*. The type specimens of the latter, being mature, suffered comparatively little from the treatment they had received; but the much softer specimens assigned to *Fabatus* had shrivelled considerably and in so doing had become distorted in such a way as to conceal their true generic characters.

Mr. Distant has recently informed us in a letter that his chief reason for regarding *Fabatus* as generically distinct was the emargination of the eyes, that is to say the concavity of their posterior margin. In fresh specimens, however, that agree in all other structural features with co-types of *F. servus*, no such concavity is apparent, but in some specimens that have been preserved for even a few hours in alcohol, shrinkage of the integument of the head and prothorax causes the eyes to protrude in the manner shown in pl. xi, fig. 4. The emargination of these organs is therefore artificial.

Euratas formidabilis, Distant.

(Plate XI, figs. 1—7.)

1910. *Euratas formidabilis* and *Fabatus servus*, Distant, vol. V, pp. 154, 155, text-figs. 82, 83.
1911. *Euratas formidabilis* and *Fabatus servus*, Annandale, *Rec. Ind. Mus.* VI, pp. 111, 112.

Distant's description of the adult of this species is excellent so far as it goes; but unfortunately he makes no mention of the structure of the external genitalia, while, owing perhaps to the position in which they are drawn, his figures of the anterior legs do not fully illustrate their peculiar structure. As regards colour, his specimens in this stage had suffered little and the only shrinkage apparent is in the prothorax in which his figure exaggerates the discal foveations.

At the distal end of the anterior tibia on its proximal side, there is in both sexes a stout blunt process about as long as the segment is wide; it fits into a groove on the ventral surface of the femur when the two segments are approximated. On the process we can find no trace in either sex of the "file" figured by Carpenter in his account of *Halobates herdmani* [1]; but in the male, immediately in front of it at the distal end of the segment, there is, as in that species, a group of slender spines, graduated in length.

The external genitalia do not differ in any important respect from those of *Halobates*. In the male (pl. xi, fig. 5) the horns of the eighth abdominal segment are symmetrical, reaching about to the middle of the ventral plate; they taper regularly to a blunt apex, which is slightly reflected outwards. Their distal ends are covered with scattered thorns that extend further forwards on the external surface than elsewhere. Dorsally, on the posterior margin of the eighth segment, there is a large rounded prominence and at each posterior angle there is a small papilla on which the spiracle opens. The ventral plate is broadly oval, convex below. The sclerite of the ninth abdominal segment is large and has the usual form; the postero-lateral margins are strongly sinuous and on each side behind the lateral prominences there is a patch of about twelve coarse spinules. We figure the female genitalia as seen from the side in an extruded condition and also, as seen from above, when retracted (pl. xi, figs. 6, 7). They resemble those of *Halobates herdmani* as figured by Carpenter (*loc. cit.*), but the ovipositor (outer posterior gonapophysis) is longer and the inner branch of the anterior appendage of larger size, while the posterior appendages extend much further beyond the basal membrane.

The egg is sausage-shaped and very long. One removed from the abdomen of a female is 1·88 mm. in length and fully three times as long as broad.

There appear to be three larval instars. In the first (pl. xi, fig. 1) the thoracic and abdominal sclerites have not yet appeared, except that there is a small chitinous plate at the extreme tip of the abdomen. The tarsus of the first leg is short and relatively broad and is composed of a single segment. The first segment of the antenna is also relatively short.

In the next instar (pl. xi, fig. 2) the prothoracic sclerite is well developed, forming a transverse bar interrupted in the middle line. On each side of the mesothorax there is a large longitudinally oval chitinous plate, while on the meta-thorax there is a pair of much smaller obliquely transverse plates, widely separated in the middle line. The tergites of the first five abdominal segments are represented by small patches of chitin placed laterally on either side and decreasing in size from before backwards. On the sixth and seventh segments these patches are scarcely distinguishable, but on the eighth there is a pair of larger plates, round and approximated to one another. The apex of the abdomen is in the same condition as in the former instar. The tarsus of the first leg has increased in length, but still consists of a single segment; the femur bears a small projection on the lower surface at

[1] Carpenter, *Ceylon Pearl Fisheries*, V, plate, figs. 5-7 (1906).

its apex, but the sexual characters of this limb are not yet apparent. The first segment of the antenna has increased in relative length.

The third instar (pl. xi, figs. 3, 4) is that described by Distant under the name of *Fabatus servus*. The sclerites are now well developed, although each is still distinctly divided into two halves and separated from those next it by a membranous interspace. The tarsus of the first leg is much longer, but still consists of one segment. The tibia exhibits the secondary sexual characters, the large tooth characteristic of the male being well developed. The femur, however, is not yet incrassated. One of us has described the colouration of this instar elsewhere; but we may note that specimens preserved in spirit give as it were a negative picture of those pinned and dried, the latter preserving to a considerable extent the natural colour of the species (*cf.* figs. 2 and 3, pl. XI)

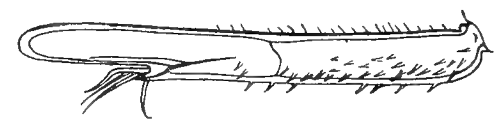

FIG. 2.—*Euratas formidabilis*, Distant. Tarsus of 1st leg of 3rd larval instar, showing the two segments of the adult tarsus within the single larval segment (from co-type of "*Fabatus servus*," Distant): × 30.

We have mounted one of Distant's co-types in Canada balsam, after clearing it with caustic potash, but we can find in it no trace of a joint in the tarsus at a level with the claws (see Distant's fig. *loc. cit.*, p. 156). The specimen was evidently just about to undergo its final ecdysis and the true position of the joint, as it occurs in adults considerably behind the base of the claws, can be detected internally (text-fig. 2). The form of the genital appendages can also be made out, although there is no external trace of them.

Euratas formidabilis occurs at all times of the year both in the main area and in the outer channel, but is perhaps more abundant in the former than in the latter. It has also been found in backwaters at Vizagapatam and Ennur on the Madras coast and was originally described from the Andamans, where it is common in sheltered bays.

It was noticed in an aquarium that disturbance of the surface of the water caused both young and adults to dive. They were, however, apparently unable to remain below for long and floated up again immediately in spite of vigorous efforts. In calm weather the adults were seen chiefly in the middle of the lake, as a rule singly or in pairs; but when the wind was high they congregated among rocks near the edge and in other sheltered spots. The young are markedly gregarious and were, as a rule, found among rocks and weeds.

The food of the species consists largely of insects that fall or are blown into the water. We have seen several individuals sucking a dead dragon-fly, but small insects are seized by single bugs. Fish-fry that swim on the surface, particularly those of *Haplochilus melanostigma*, are also eaten. Prey is held not between the femur and tibia of the first legs, but between the inner surfaces of the two femora.

The male clasps the female with his anterior femora immediately behind her front legs, the spines on the femora assisting in maintaining a hold. It is noteworthy that in *Asclepios annandalei*[1], in which the spine characteristic of the male is situated on the femur instead of on the tibia, the female is gripped much further back, immediately in front of the third pair of legs.

[1] Distant, *Ann. Mag. Nat. Hist.* (8) XV, p. 504, text-figs. (1915).

Order *DIPTERA.*

A large number of species of this order breed during the rains, and especially after their cessation, when the water-level of the lake is sinking, in small pools near the margin of the lake. In the waters of the lake itself we found, however, the immature stages of only three flies—*Eristalis arvorum*, *Anopheles rossii* and a species of *Palpomyia*. All of these were common in the right season at suitable localities, the larvae of *E. arvorum* in decaying weed at the edge, those of the two Nematocera among thickets of *Potamogeton*. The larvae of all three species are evidently able to endure considerable changes in salinity.

Family **Syrphidae.**

1915. *Eristalis arvorum*, Fabricius, Brunetti, *Rec. Ind. Mus.* XI, p. 228 (pl. XI, figs. 8, 9).

We have to thank Mr. Brunetti for identifying flies of this species, which he states to be the commonest Indian representative of the genus.

The larva (pl. xi, figs. 8, 9) resembles the European species figured by Miall[1], but differs in the following points,—(i) the inner branch of the terminal part of the

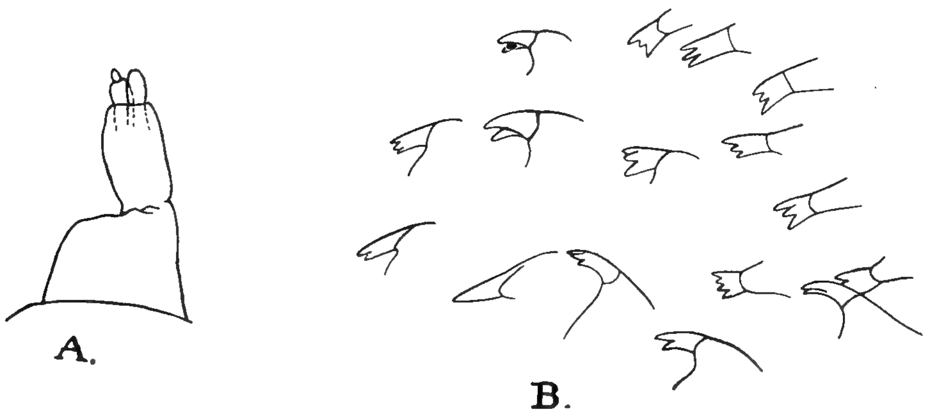

FIG. 3.—*Eristalis arvorum*, Fabricius.
A. Lateral view of sensory papilla of larva: ×75.
B Spines on anterior extremity of body of larva: ×250.

sensory papillae consists of two barrel-shaped segments, of which the basal one is considerably the larger (text-fig. 3 A); (ii) the spines at the anterior extremity of the body are bifid or trifid, except on the posterior part of the area they cover, where they are simple (text-fig. 3 B); (iii) there are about eleven chitinous ridges on each side of the antechamber of the pharynx; (iv) the posterior part of the body is more densely covered with hair which extends on to the base of the tail; (v) the processes at the base of the tail are shorter and concealed by the hair.

Flies of this species were observed in large numbers on two occasions, flying round rocks at the margin of the lake and settling at the edge of the water, in March near Patsahanipur and in November on Kalidai Id. The larvae were found among rotting weed on both occasions. The species is widely distributed in the Oriental region.

[1] Miall, *Nat. Hist. Aquatic Insects*, p. 198, figs. 70-77 (1895).

Family Chironomidae.

It is probable that several species of this family breed in the lake during the freshwater season, and we have frequently seen large numbers of larval skins floating on the surface of the main area at this time of year; many species certainly breed in small pools near the edge. This is probably the case with at least one blood-sucking form (*Culicoides peregrinus*, Kieff.) very common at Barkul in July and September.[1] Immature stages of only one Chironomid were, however, taken in the lake itself.

The species belongs to the genus *Palpomyia*, but seems to be distinct from any of those described from India. It is perhaps allied to *P. polysticta*, Kieffer,[2] which it resembles in the colour of its thorax, but all the femora and tibiae are dark brown, only slightly pale at the joints, while the tarsi are white with black rings at the joints and with the distal segment brownish. The abdomen of the female is white below, at any rate in spirit, except for the last two segments, and the dorsal surface appears to be brownish with ill-defined white spots.

Although the pupal stage, of which we give a figure (pl. xi, fig. 10) was common in the *Potamogeton* thickets of Balugaon Bay in February and March, we did not succeed in finding the larva. The fly was seen in considerable numbers on the surface of the water and a few specimens were hatched out in an aquarium.

Family Culicidae.

Major A. B. Fry in reference to the Chilka Lake writes as follows[3]:—"Villages are built on the very borders of the lake, and though most of them have a few patches of rice cultivation the vast perennial mosquito population comes from the lake itself. In situations sufficiently protected by weeds and algae from the attacks of fish, anopheline larvae and nymphs are in veritable swarms. The majority were *Pm. rossi* and *N. fuliginosus*, but *M. listoni* were present. My second visit was to look for *Pm. ludlowi*, in consequence of Christophers' observations in the Andamans; but I found none, but discovered *M. fowleri* and *M. nigerrimus*."

Notwithstanding a careful search at many localities, the only mosquito larvae we were able to find in the lake were those of *Anopheles rossii*, Giles, which were abundant among weeds off Barkul in February and July in water of specific gravity 1·0075 to 1·008 and also off Nalbano in September in fresh water. The absence of *A. ludlowi* is somewhat remarkable, as it is the common Anopheline in brackish water in the neighbourhood of Calcutta.

Major Fry's visits to the lake were made in January; in March and September we failed to find even *A. rossii* off Satpara, and our impression is that most of the mosquitos breed in small pools of water near the edge rather than in the lake itself.

We have to thank Major Christophers for confirming our identification of *A. rossii*.

[1] *Rec. Ind. Mus.*, IX, p. 246 (1913). [2] *Rec. Ind. Mus.*, VI, p. 116 (1911).
[3] *First Report on Malaria in Bengal*, p. 35 (Bengal Secretariat, Calcutta, 1912).

Order *LEPIDOPTERA.*

Family **Pyralidae.**

In thickets of *Potamogeton* off Barkul the larvae of a small moth, *Nymphula diminutalis*, Snell, was abundant in the dry season, being able to endure a salinity equivalent to a specific gravity of 1·008. The same species breeds in brackish water in the Gangetic delta, but is found also in many inland localities, having a wide distribution in the Oriental region and beyond.

The caterpillar constructs its case, which closely resembles that of a Caddis-worm, out of the narrow leaves of various water plants, arranging them parallel to one another in a longitudinal direction.

Mr. Meyrick has been kind enough to identify a moth of this species reared from a caterpillar found feeding on *Nais* in brackish water at Port Canning.

II. MARGINAL INSECTS.

The insects to be considered under this heading include three species of Dermaptera, one Orthopteron and three Rhynchota. At least two species of Collembola were also obtained in damp sand at the edge of the lake, but we are unable to express any opinion as to their identity. We may also refer to the curious Heterocerid beetle (*Heterocerus maindroni*, Grouvelle)[1] which burrows in sand and sandy mud to a point well below the water-level of the lake, taking to its wings at night and often flying to the lamps of bungalows in the neighbourhood. It occurs at the margin in places where the water is as salt as that of the Bay of Bengal near the lake, as well as where it is fresh.

The three earwigs are *Labidura bengalensis*, Dohrn, *L. riparia* (Pallas) and *Forcipula quadrispinosa*, Dohrn. Of these the two former are doubtfully distinct. All occur commonly under stones and particularly under alga that has dried on rocks; the *Forcipula* is a good swimmer, while *Labidura* can endure immersion in both fresh and salt water. The species are also found in similar situations at the edges of streams and ponds. *L. riparia* is a cosmopolitan species, while *L. bengalensis*, if it is distinct, is widely distributed in India and Ceylon; *F. quadrispinosa* is found also in Burma and the neighbouring countries.

The Orthopteron is a mole-cricket that agrees in every respect with the specimens identified by the late Mr. Kirby as *Curtilla* (=*Gryllotalpa*) *africana*, Beauv. It is nocturnal in its habits and usually burrows in mud at the edge of water. At Satpara it was found burrowing well below water-level in the salt-water season and its song may be heard at all parts of the lake in the evening. *Gryllotalpa africana* is the common species of the plains of India; its distribution is given as "Africa, Asia, Australia, N. Zealand (introd. ?)"[2]

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[1] Grouvelle, *Ann. Soc. ent. France*, LXXII, p. 345, fig. (1903).

[2] Kirby, *Syn. Cat. Orthopt.*, II, p. 6 (1906).

The three species of Rhynchota that may be classed as marginal forms are *Ochterus marginatus*, Latr., of the family Ochteridae or Pelogonidae, *Pirates lepturoides* (Wolff) of the family Reduviidae and *Leptopus assuanensis*, Costa, of the family Saldidae. The first of these is a diurnal species, often very common on mud at the edge of lakes and ponds. It is abundant in this situation at the Sar Lake in the Puri district, but at the Chilka Lake we only obtained one specimen, found on the surface of floating weeds in Gopkuda Bay. *Ochterus marginatus* occurs in Central Europe and South Africa and is doubtless widely distributed in the Oriental region. *Pirates lepturoides* apparently resembles *Gryllotalpa africana* in its habits. It was found in considerable numbers in damp sandy mud near Barhampur Id. in March and under stones near Barkul in the same month. The species has been recorded from several localities in India, Ceylon, Burma, Java and Borneo. *Leptopus assuanensis* is an active diurnal species very abundant among rocks in the main area; it flies about rapidly from rock to rock and settles just above the water-level. The species was described from Egypt and occurs also in Nubia and Madagascar as well as in many Indian localities, some of which are situated far inland.

From the foregoing notes it is clear that the marginal insects of the Chilka Lake, like most of the aquatic forms, are species of very wide distribution, capable of surviving temporary immersion in salt as well as in fresh water.

EXPLANATION OF PLATE XI.

Euratas formidabilis, Distant.

FIG. 1.—First larval instar, from a specimen preserved in alcohol.

,, 2.—Second larval instar, from a specimen preserved in alcohol.

,, 3.—Third larval instar (= *Fabatus servus*, Distant) from a fresh specimen.

,, 4.—Head and pronotum of third larval instar, from a specimen immersed in alcohol for twenty-four hours and then dried (more highly magnified than fig. 3).

,, 5.—Male genitalia as seen from below, from a preparation mounted in Canada balsam: $\times 20$.

The dorsal sclerite of the ninth segment has been thrust to one side and its lateral angles are somewhat folded inwards in order to show the group of spines near the margin on the dorsal surface.

,, 6.—Female genitalia as seen from above in a retracted condition after removal of the 8th dorsal sclerite, from a specimen mounted in Canada balsam: $\times 30$.

a. Genital aperture.
b. Genital hood.
c. Anterior appendage.
d. Inner branch of anterior appendage.
e. Ovipositor.
f. Posterior appendage.
g. 10th abdominal segment.
h. Anal segment.

,, 7.—Female genitalia, lateral view in extended condition, slightly diagrammatic: $\times 30$.

Lettering as in preceding figure.

Eristalis arvorum, Fabricius.

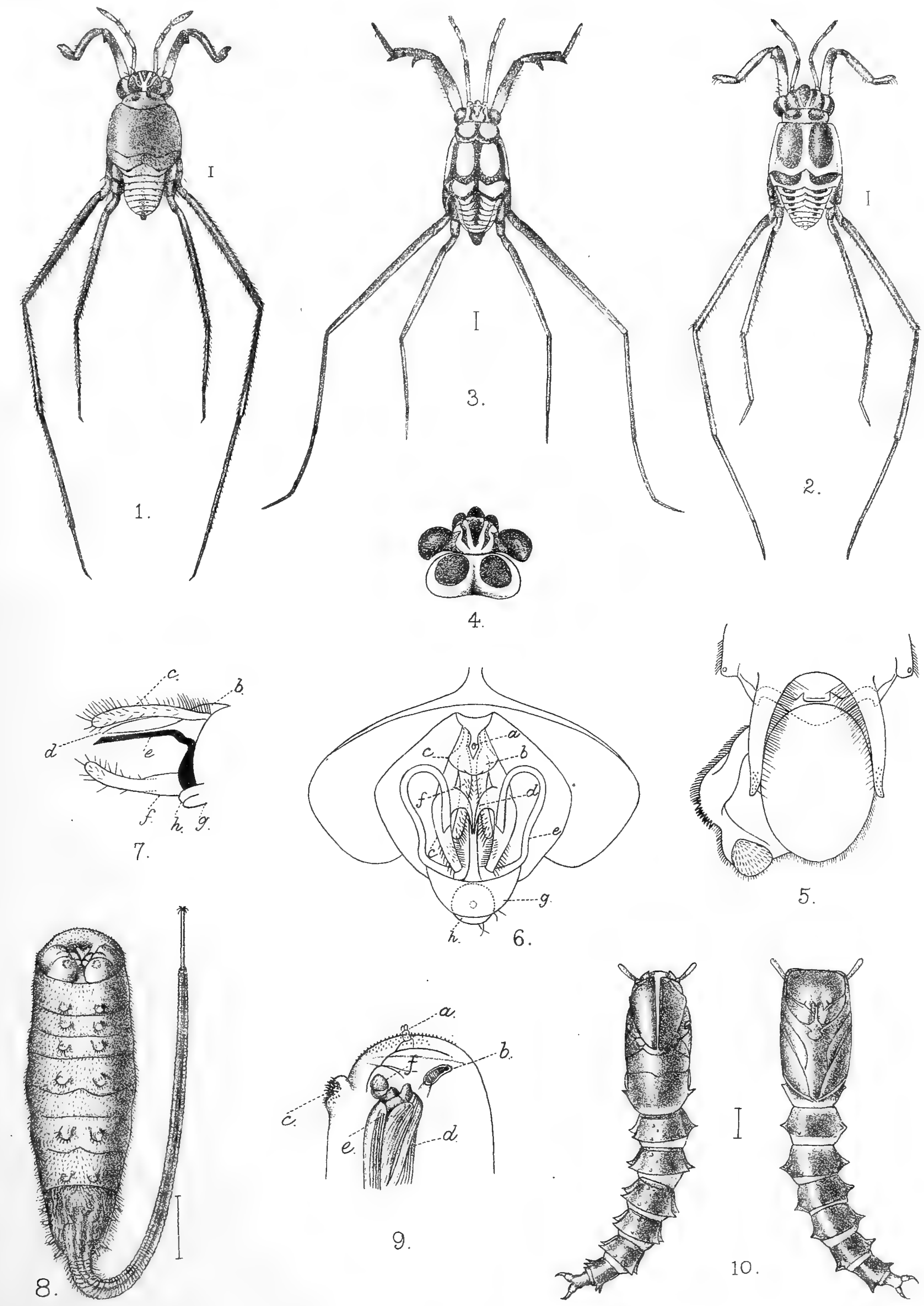
FIG. 8.—Ventral view of larva with tail partly retracted.

,, 9.—Lateral view of anterior extremity of larva, viewed as a transparent object: $\times 8$.

a. Sensory papilla.
b. Anterior extremity of the lateral tracheal trunk.
c. First foot.
d. Pharynx.
e. Chitinous skeleton of pharynx.
f. Antechamber of pharynx.

Palpomyia sp.

FIG. 10.—Dorsal and ventral views of cast pupal skin.



G. M. Henry & D. N. Bagchi, del.

A. C. Chowdhary, lith.

INSECTS OF THE CHILKA LAKE.

FAUNA OF THE CHILKA LAKE

STOMATOPODA.

By Stanley Kemp, *B.A.*

(With 2 text-figures.)

CONTENTS.

STOMATOPODA.

By Stanley Kemp.

Two species and one variety of Stomatopoda have been found in the Chilka Lake, but the only one that is abundant is *Squilla scorpio* var. *immaculata*, a form also common in brackish water in the Gangetic delta. The occurrence both of *S. scorpio* and its variety *immaculata* is of some interest, for the two had not hitherto been found together. No specimens intermediate in character were observed, and it is possible that the two forms should more properly be recognised as distinct species. A knowledge of the early stages might throw light on this point; but all the larvae found in the lake are of one type and, if a difference exists in the structure of the *Alima*, they belong presumably to the more abundant var. *immaculata*. The third form, *Squilla interrupta*, seems to be merely a casual visitor to the lake-system, in which only one example has been found. This species and the typical form of *S. scorpio* have a wide Indo-pacific distribution, while the variety *immaculata* is known from an area extending from the mouth of the Indus to the coast of Burma.

Family SQUILLIDAE.

Genus **SQUILLA**, Fabricius.

Squilla scorpio, Latreille.

1913. *Squilla scorpio*, Kemp, *Mem. Ind. Mus.*, IV, p. 42, pl. ii, fig. 30.

The typical form of this species is very scarce in the Chilka Lake; it is represented in our collection by two males and eight females, the largest 67 mm. in length. The black patch on the lateral process of the fifth thoracic somite is conspicuous in all the specimens, even in the smallest, an individual only 21 mm. long.

Squilla scorpio was found both in the main area and in the outer channel of the lake in water varying in specific gravity from 1·000 to 1·0265. It is known to be distributed over an area extending from the east coast of India to N. Australia and Celebes and has, apparently, hitherto been obtained only in the sea.

var. **immaculata**, Kemp.

1913. *Squilla scorpio* var. *immaculata*, Kemp, *Mem. Ind. Mus.*, IV, p. 45, pl. ii, fig. 31.

Squilla scorpio var. *immaculata* is one of the commonest Crustaceans in the main area of the lake, occurring on a muddy bottom at all seasons of the year. It was also obtained on similar ground at the inner end of the outer channel and is able to exist, and apparently to breed also, in water varying in specific gravity from 1·000 to 1·0265.

Although both the typical form and the variety have been obtained at a number of localities on the Indian coast, this is the first occasion on which the two have been found together. It is therefore interesting to notice that in the Chilka Lake they are very easily distinguished and that in our long series no single individual intermediate in character was obtained. In specimens of the variety in which the pigmentation is unusually dense, the lateral process of the fifth thoracic somite is occasionally somewhat dusky, but never dark enough to cause confusion with the typical form, while the correlated structural differences in the shape of the rostrum and carination of the carapace will also suffice to separate the one from the other. It seems, indeed, not by any means improbable that the variety *immaculata* will ultimately be given specific rank; but, apart from colour, the distinctions are so slight that it is inadvisable to take this course with the information we at present possess. A knowledge of the early stages of the two forms will perhaps afford a useful clue, but the series of larvae obtained in our tow-nettings are all of one type. In view of the great numerical preponderance of the variety *immaculata*, it seems probable either that they belong to this variety or that the varietal and typical forms are indistinguishable in their early stages.

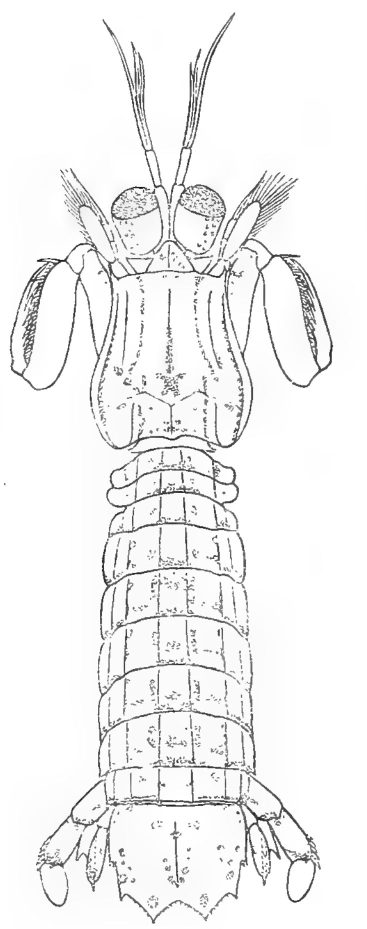


FIG. 1.—*Squilla scorpio* var. *immaculata*, Kemp.
A post-larval specimen about 8 mm. in length.

Specimens of the variety were obtained in the trawl in many places both in the outer channel and in the main area and were found in the salt-water season, when the water-level was at its lowest, under stones on the shore of Barkuda Id., living in burrows. The burrows were about half an inch in diameter and were U or Y-shaped, the distance between the openings being about eight inches. On lifting the stone the whole burrow was sometimes disclosed; it frequently contained practically no water. The *Squilla* occupied a slightly widened chamber at the bend of the U or in the stalk of the Y. Specimens were also observed at the head of Rambha Bay, on mud-flats left bare owing to the action of strong wind. They lay at the mouth of their burrows, which were directed vertically downwards for about 3 inches before turning horizontally over a layer of shingle. No individuals with egg-masses were observed.

POST-LARVAL FORMS.

Our collection contains twenty-seven specimens less than 30 mm. in length which may conveniently be termed post-larval. The series apparently comprises four stages, the lengths of which are approximately 7·5—8·0 mm., 11·5—12·0 mm., 15·5—16·0 mm. and 25—27 mm. There are, however, one or two specimens of intermediate sizes.

The youngest post-larval stage (text-fig. 1) bears a close resemblance to the adult, but the eyes are proportionately much larger, the rostrum is broader at the base

and more strictly triangular in outline, the lateral margin of the fifth thoracic somite is scarcely at all produced and the telson still possesses between the marginal teeth the fine widely-separated spinules characteristic of the larval stages.

The single post-larval specimen of the typical *S. scorpio*, an individual 21 mm. in length, is easily distinguished from examples of the var. *immaculata* measuring 16 and 25 mm. by the same characters that serve to separate the adults. All post-larval specimens of 16 mm. in length and under apparently belong to the variety, lacking the characteristic features of the typical form. It appears to me probable that the two are to be distinguished even in the earliest post-larval stages and that such stages of the typical *S. scorpio*, a form comparatively rare in the Chilka Lake, are absent from our collections. There is, of course, a possibility that the two are inseparable until they have reached a length of about 2 cms.

Larval Forms.

The larval forms found in the Chilka Lake are all of one type and the majority are doubtless those of *S. scorpio* var. *immaculata*. The larvae of the typical form were either not obtained or are inseparable from those of the variety.

The largest larvae in the collection (text-figs. 2*a-c*) are from 11·5 to 12·0 mm. in length from the tip of the rostrum to the apex of the telson. The rostrum is not as long as the carapace, the antero-lateral spines are shorter, in length scarcely equal to half the anterior breadth of the carapace, while the postero-laterals are long, about two-thirds as long as the distance between the antero-lateral angles and the posterior margin. The carapace is carinate in the mid-dorsal line, the carina terminating posteriorly in a spine, directed obliquely upwards and backwards, that is fully one-third the length of the postero-laterals. The lower edge of the rostrum, a little behind its middle point, is provided with one, less commonly with two, spinules. On the lateral margin of the carapace are three spinules, one close to the antero-lateral spine and two in the posterior quarter of its length (text-fig. 2*c*). On the inferior aspect of each postero-lateral spine is a sharp spinule and another, which appears to be highly characteristic of this particular larva, is found on each side of the posterior margin midway between the postero-median and postero-lateral spines.

The eyes are comparatively large, the basal portion of the stalk being very slender. The penultimate segment of the raptorial claw bears, on the margin opposed to the dactylus, two stout basal teeth, beyond which is a series of fine pectinations. The dactylus shows no trace of teeth (text-fig. 2*b*).

The appendages of the last three thoracic segments are well developed and biramous; only the last segment is exposed in dorsal view. The postero-lateral angles of the abdominal somites are not provided with spines and there are no spines on the posterior margin of the last segment. The pleopods are well formed but do not bear gills.

The telson is a trifle broader than long and is carinate mid-dorsally. There are eight pairs of spinules between the submedian teeth, five to seven spinules between the submedians and intermediates and one between the intermediates and laterals.

The uropods reach midway between the lateral and intermediate teeth of the telson; the basal segment of the outer uropod bears a series of spinules on its outer edge.

The two other larval stages in the collection are approximately 9·0—9·5 mm. in total length (text-fig. *2d*) and 7·3—8·0 mm. in length (text-figs. *2e, f*). At all stages there is a certain amount of variation in the length of the rostral and postero-lateral spines. This variation is most marked in the youngest stage; text-fig. *2g* is an illustration of a specimen in which the spines are exceptionally long.

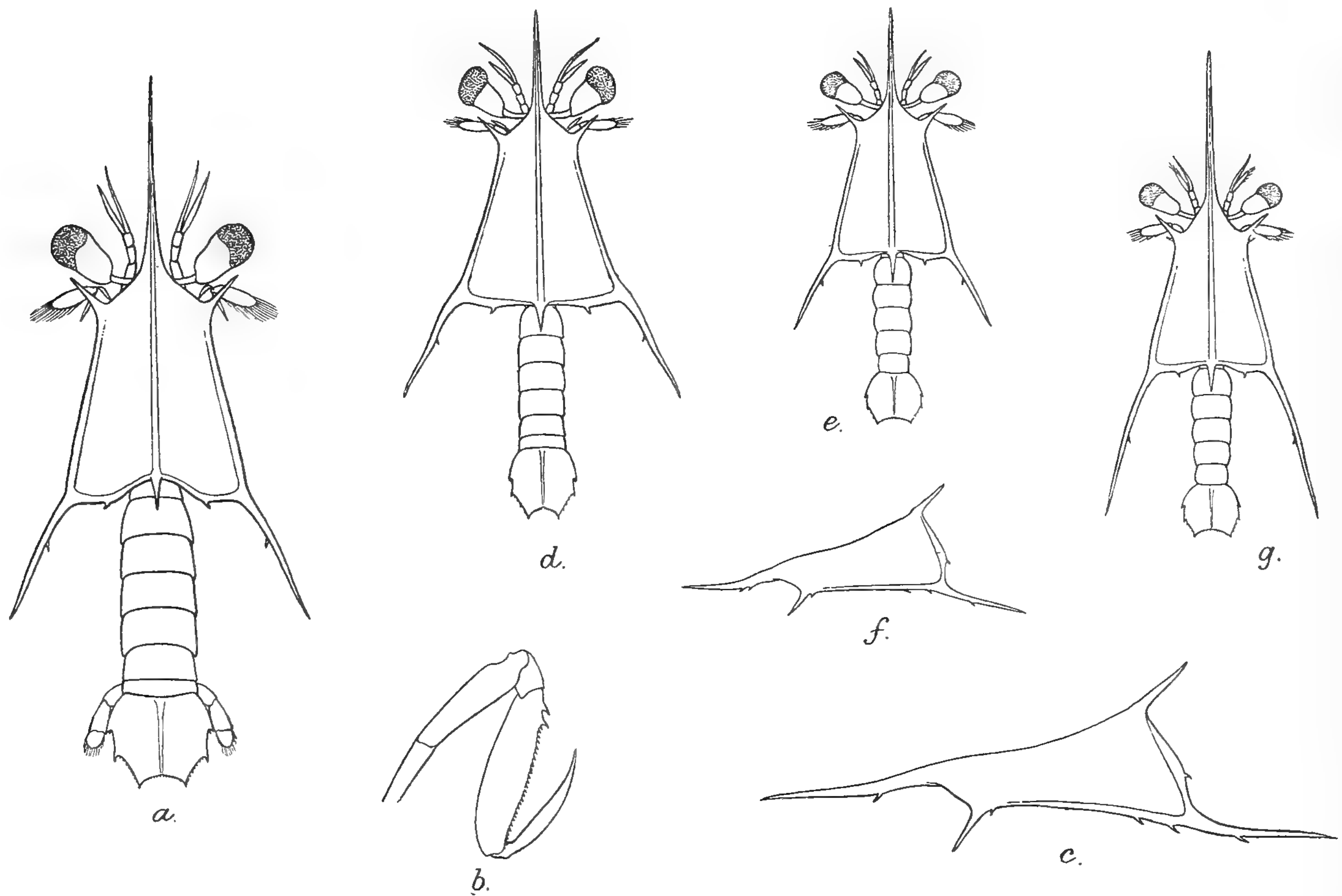


FIG. 2.—*Squilla scorpio*, Latreille.
Larvae presumably belonging to the var. *immaculata*.

a. Larva belonging to the largest stage obtained.
b. Raptorial claw of the same larva.
c. Carapace of the same larva in lateral view.
d. Larva belonging to an intermediate stage.
e. Larva belonging to the youngest stage obtained.
f. Carapace of the same larva in lateral view.
g. Larva belonging to the same stage, with abnormally long rostral and postero-lateral spines.

The pair of small spinules on the posterior margin of the carapace is developed in all three stages; by this character the *Alima* of *S. scorpio* var. *immaculata* appears to be sharply distinguished from all larvae hitherto described.

All the larvae obtained were found during the months of February, March and July, at a time when the water of the lake was almost or quite at its saltest. Reproduction probably commences early in the year, as soon as the first influx of salt water from the Bay of Bengal has taken place.

Squilla scorpio var. *immaculata* has been recorded from Karachi, from the Gangetic delta and from the Arakan coast. In the vicinity of Calcutta, a locality in which the typical form has never yet been found, it is far from uncommon, living in water of low but variable salinity.

Squilla interrupta, Kemp.

1913. *Squilla interrupta*, Kemp, *Mem. Ind. Mus*, IV, p 72, pl. v, figs. 60-62.

A single specimen of this species, a male 77 mm. in length, was obtained by Mr. T. Southwell in August, 1913, from fishermen at Satpara. The specimen was undoubtedly found in the outer channel of the lake, and if, as seems probable, the periodic changes in salinity in 1913 were the same as those of 1914, the individual must have been found in fresh water.

We obtained no specimens during our survey of the lake and are inclined to regard the species merely as a casual immigrant to the outer parts of the lake-system. *Squilla interrupta* is common on the Orissa coast of the Bay of Bengal and is known to have a distribution extending from the Persian Gulf to Formosa and Hongkong.

EXPLANATION OF PLATE XII.

FIG. 1.—*Ebalia malefactrix*, sp. nov., male × $2\frac{1}{2}$ (p. 209).

,, 2.—*Philyra alcocki*, sp. nov., male × $2\frac{1}{4}$ (p. 212).

,, 3.—*Elamena* (*Trigonoplax*) *cimex*, sp. nov., female × $2\frac{1}{2}$ (p. 216).

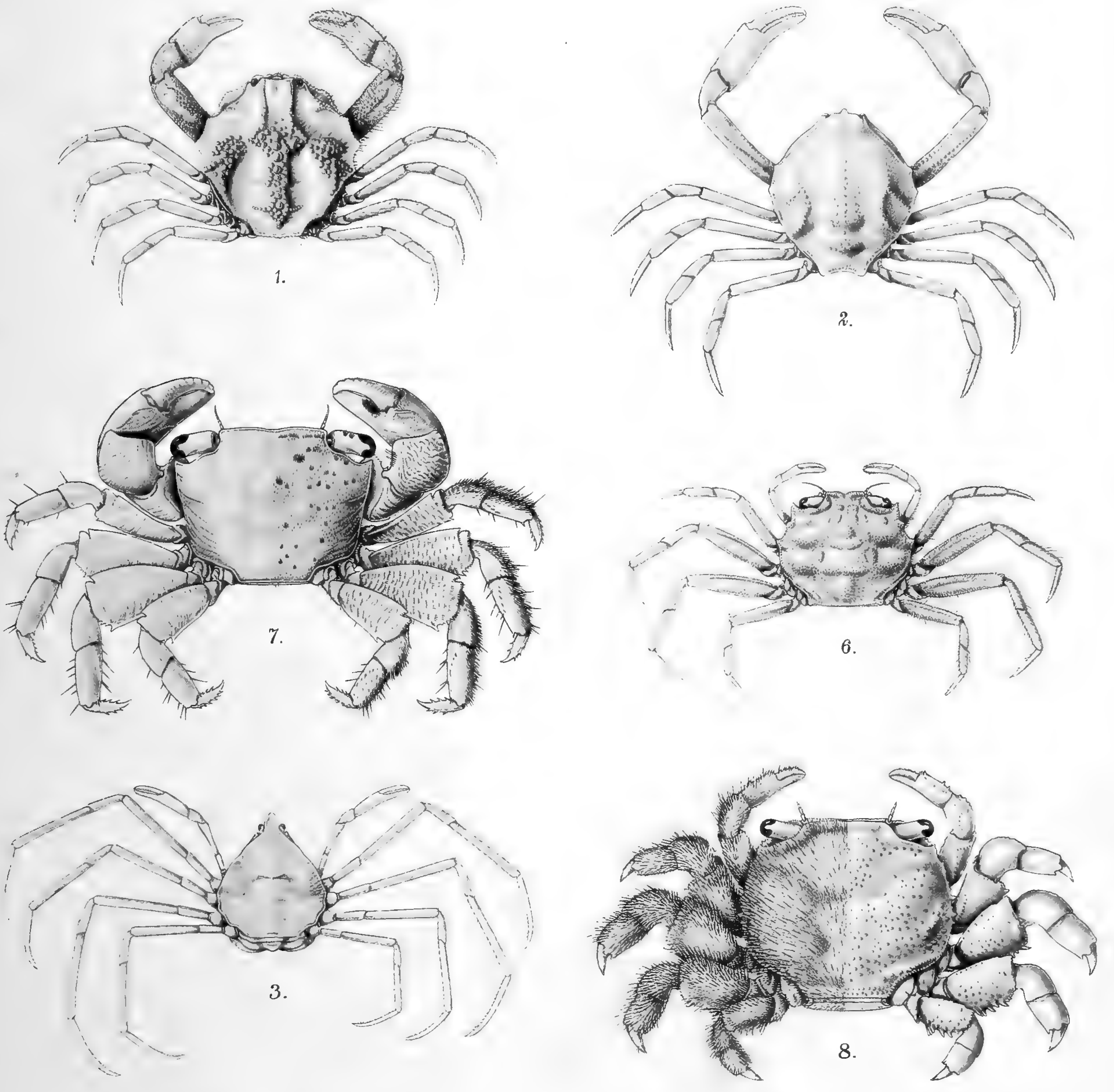
,, 4.—*Dotilla pertinax*, sp. nov., male × 4 (p. 222).

,, 5.—*Macrophthalmus gastrodes*, sp. nov., male × $1\frac{1}{3}$ (p. 228).

,, 6.—*Camptandrium sexdentatum*, Stimpson, young male × $5\frac{1}{3}$ (p. 236).

,, 7.—*Sesarma batavicum*, Moreira, male × $3\frac{1}{2}$ (p. 238).

,, 8.—*Leipocten sordidulum*, gen. et sp. nov., female × $4\frac{3}{4}$ (p. 244).



S. C. Mondul, del. Bemrose, Collo., Derby.

CRUSTACEA DECAPODA OF THE CHILKA LAKE.

EXPLANATION OF PLATE XIII.

Callianassa (Callichirus) maxima, A. Milne-Edwards (p. 253).

FIG. 1.—Anterior part of carapace, rostrum, eyes, etc. of the specimen from Madras: × 2·5.

,, 2.—Large chelipede of the same specimen, external view: × 1·25.

,, 3. Ditto ditto internal view: × 1·25.

,, 4. Ditto from the Chilka Lake, external view: × 1·58.

,, 5.—Last abdominal somite, telson and uropods of the specimen from Madras: × 1·9.

Upogebia (Upogebia) heterocheir, sp. nov. (p. 257).

FIG. 6.—Anterior part of carapace, rostrum, eyes, etc.: × 6·3.

,, 7.—Last abdominal somite, telson and uropods: × 5.

Pontophilus hendersoni, sp. nov. (p. 261).

FIG. 8.—A male, dorsal view: × 5.

Urocaris indica, sp. nov. (p. 275).

FIG. 9.—An ovigerous female, lateral view: × 5.

Periclimenes demani, sp. nov. (p. 279).

FIG. 10.—A male, lateral view: × 4·4.

Alpheus paludicola, sp. nov. (p. 303).

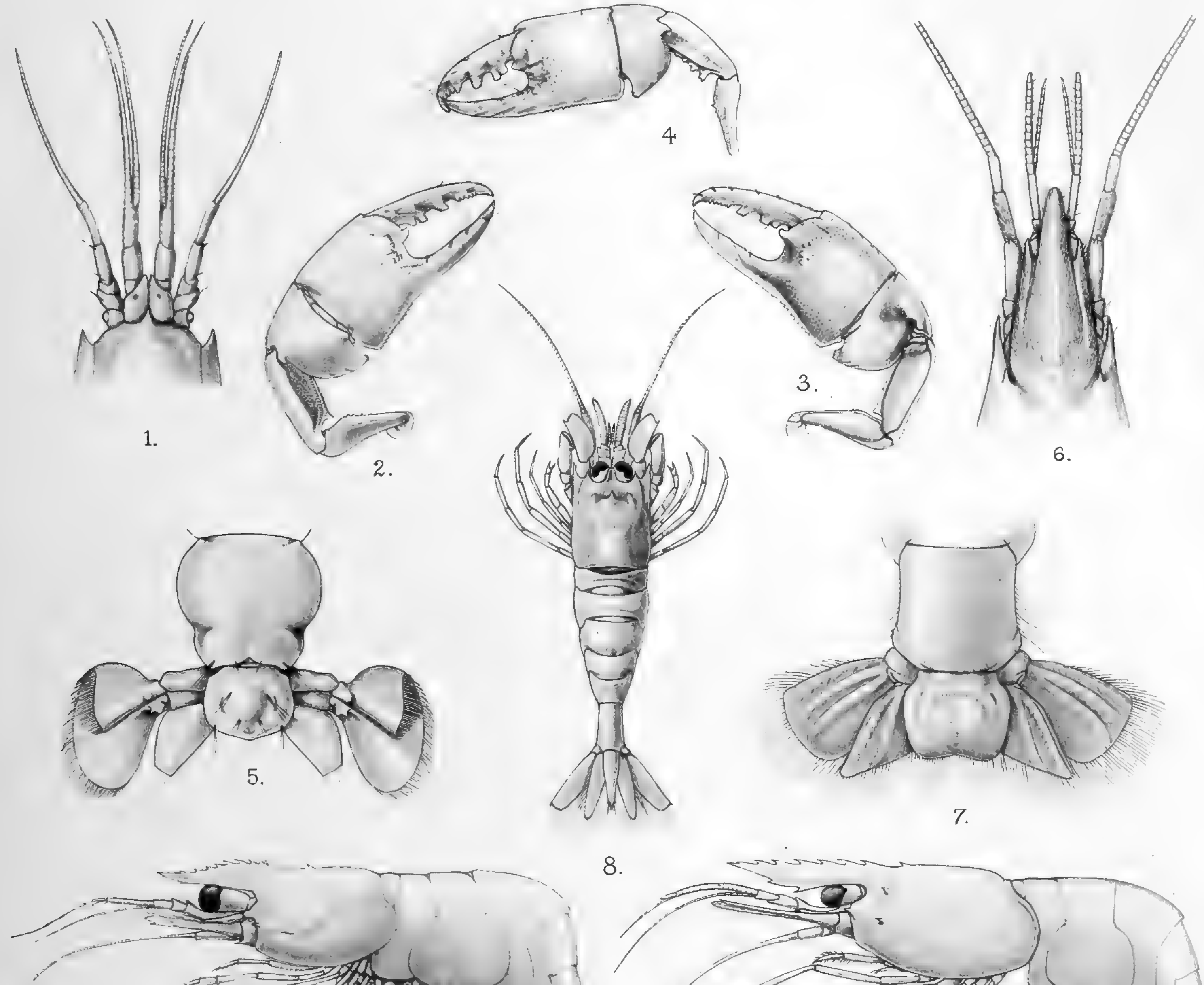
FIG. 11.—Anterior part of carapace, rostrum, etc.: × 5.

,, 12.—Large chelipede, external view: × 3.

,, 13. Ditto , internal view: × 3.

Leptochela aculeocaudata, Paulson (p. 311).

FIG. 14.—Carapace of a female, with eyes, antennules, etc. in dorsal view: × 10.



A.C.Chowdhary, del.

Bemrose, Collo_Derby.

CRUSTACEA DECAPODA OF THE CHILKA LAKE.

MEMOIRS OF THE INDIAN MUSEUM, VOL. V.

FAUNA OF THE CHILKA LAKE

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FAUNA OF THE CHILKA LAKE

CRUSTACEA DECAPODA.

By Stanley Kemp, B.A.

(Plates XII, XIII.)

CONTENTS.

CRUSTACEA DECAPODA.

By STANLEY KEMP.

The Crustacea Decapoda form an important part of the fauna of the Chilka Lake and comprise, including casual visitors, fifty-four species. At least thirty-nine are permanent inhabitants and it is not a little surprising that so large a number of forms should have adapted themselves to the peculiar physical conditions that prevail in the lake-system.

The results of our observations on the physical environment of the fauna have already been discussed in detail in the Introduction to this volume: but it will be well to recapitulate here one or two of the more salient features.

The lake, which lies on the coast of Orissa, may be divided into two regions, firstly the main area, a large lagoon fed by rivers from the northern end only and even in the flood-season nowhere more than 15 ft. in depth, and secondly the outer channel, some twelve miles in length and but little deeper than the main area, which forms a communication with the sea. The bottom of the main area is mud, or mud with a small admixture of sand; in the outer channel it is composed of muddy sand in the inner portion and of clean sand nearer the mouth. It is, however, the great seasonal changes in salinity that constitute the most noteworthy feature of the physical conditions. In August, towards the close of the rainy season, the level of the lake is considerably higher than at other times of the year, owing to the great volume of fresh water which is poured into it from the north. The fresh water expels most of the salt water from the lake, with the result that during August and the two succeeding months the northern portion of the main area and the whole of the outer channel up to the sea-mouth are completely filled with water that shows no trace of salinity. The southern end of the lake always remains slightly brackish, though during these months it is far less saline than at other times of the year. By the end of October the floods begin to subside and later, under certain conditions of wind and tide, salt water from the Bay of Bengal enters the outer channel and the main area. For a considerable part of the year the outer channel remains filled with water of the same density as that of the Bay of Bengal in the vicinity of the sea-mouth (sp. gr. 1·0265). In the main area it is improbable that so high a density is ever reached, for a certain amount of fresh water is constantly entering the lake from the north. According to our observations the specific gravity does not rise above 1·0150.

It is evident, then, that species that permanently inhabit the outer channel can withstand seasonal alterations of salinity varying from that of fresh water to that of water as salt as the sea in the neighbourhood of the lake, while those that exist in

the main area throughout the year can survive in a medium varying from fresh water to water of specific gravity 1·0150.

The species of Decapoda found in the course of our investigations in the Chilka Lake are listed on pp. 204, 205. Each species is classified biologically as a permanent inhabitant, a seasonal immigrant, or a casual visitor; the range of salinity which it can withstand in the lake is noted and indication is made of its habitat, whether found in the main area or the outer channel, with a brief note on its further distribution.

About 60 per cent of the total number of species are able to exist throughout the whole range of salinities that occur.

The permanent inhabitants, those that are found in the lake throughout the year, form the most important part of the Decapod fauna and comprise the great majority of the species obtained. Among them, as might be expected, are representatives of a number of families known to inhabit brackish water. Such are the Hymenosomatidae, Grapsidae, Ocypodidae, Geocarcinidae, Portunidae, Atyidae and Penaeidae. Several of the genera met with were, however, known hitherto only from the sea and precise indications of the salinity that the others are able to endure has in most instances been lacking. The Leucosiidae and Xanthidae are marine types whose presence in fresh and brackish water is unexpected and this is also true of the majority of the Alpheidae[1], the Palaemonid genera *Urocaris* and *Periclimenes* and the planctonic Sergestid, *Lucifer*.

The only representatives of freshwater genera that can be classed as permanent inhabitants are the two species of *Caridina*.

So far as our present knowledge goes, the following species are confined to estuarine tracts and lagoons, that is to say, to waters communicating directly with the sea, but of low or variable salinity :—

Ebalia malefactrix.	*Leipocten sordidulum.*
Philyra alcocki.	*Clibanarius olivaceus.*
Elamena (*Trigonoplax*) *cimex.*	*Upogebia* (*Upogebia*) *heterocheir.*
Macrophthalmus gastrodes.	*Periclimenes demani.*
Pachygrapsus propinquus.	*Ogyrides striaticauda.*

Alpheus paludicola.

No Oxyrhyncha[2], Dromiacea, Hippidea, Galatheidea, Palinura or Stenopidea were obtained in the lake. Among the Brachygnatha it is singular that no representatives of the Pinnotheridae and Gonoplacidae occur. Many of the species belonging to these two families are mud-dwellers and, judging from the account which Miss Rathbun has given[3], they constitute a very important part of the fauna of the inshore waters of the Gulf of Siam.

[1] One member of this family, *Alpheopsis haugi,* is indeed known from a freshwater lake in French Congo (see Coutière, *Bull. Mus. d'Hist. nat. Paris*, 1906, p. 376).

[2] The family Hymenosomatidae, one species of which occurs in the lake, is sometimes included in this tribe. I have followed Alcock in placing it in the Brachyrhyncha.

[3] Rathbun, *Danske Vid. Selsk. Skrift.* (7), *Naturvid. og. math.*, V, p. 302 (1910).

The species classed as seasonal immigrants are particularly interesting. Of the only crab included in this category, *Gelasimus annulipes*, a well-established colony was found in the outer channel in the salt-water season. The colony inhabited one of the islands in this region and was composed of small and half-grown individuals, some of which were probably hatched in the lake. In the freshwater season, when the floods had raised the water-level of the channel by several feet, making a considerable reduction in the size of the island, we were unable to find any trace of the species. It is evident that with the arrival of the fresh water the colony was either exterminated or was compelled to change its quarters. Unfortunately we were unable to determine whether the appearance of the species in the outer channel is an annual event.

Concerning two other species that are classed as seasonal immigrants, *Palaemon malcolmsoni* and *P. rudis*, we are able to offer evidence of a more satisfactory nature. Towards the close of the monsoon these species are common in the main area and are trapped in large numbers by the Uriya fishermen. Their appearance in the lake is unquestionably an annual event coinciding with the freshwater season. During this period egg-bearing females of *P. malcolmsoni* alone were seen, whereas in the case of *P. rudis* adult males were commonly found together with ovigerous females. Except for a series of small ovigerous females obtained at Satpara in salt water, which I attribute with very considerable doubt to *P. malcolmsoni*, no adult *Palaemon* were found in the lake during the salt-water season and the species are so large and specimens are so numerous during the freshwater period, that it is scarcely possible that we can be mistaken on this point. The adults must therefore migrate to the lake annually from the ponds and streams of fresh water in its vicinity, and it is significant that this migration coincides with the period when the females bear eggs and that in one of the two species it is undertaken only by this sex. The only possible explanation is that the females resort to the lake to hatch out their young in its waters, an explanation which is corroborated in the case of *P. rudis* by the fact that we obtained at different localities, and at all times of the year, young forms that could definitely be associated with this species.

Palaemon lamarrei is also classed as a seasonal immigrant. As in the case of *P. malcolmsoni* only ovigerous females were found; but these were obtained exclusively in the salt-water season, in water of specific gravity varying from 1·008 to 1·011. The species apparently enters the lake for the same purpose as the other two, but apparently prefers brackish water.

The migrations of the Palaemonidae in the Chilka Lake are most remarkable, for all the species are known to occur in fresh water in localities from which access to tidal creeks and lagoons is clearly impossible.

Eleven species we regard as casual visitors to the lake, ten being immigrants from the sea and one from fresh water. In the outer channel in March, when the water was as salt as that of the Bay of Bengal in the vicinity of the lake, *Pontophilus hendersoni* occurred near the sea-mouth, and on the sand-banks in the same

Species.	Permanent inhabitant.	Seasonal immigrant.	Casual visitor.	Specific gravity of water.	Distribution in lake. Main Area.	Distribution in lake. Outer Channel.	Further distribution.
REPTANTIA							
OXYSTOMATA							
CALAPPIDAE.							
Matuta victor (Fabricius)	..	..	×	1·0265	..	×	Indo-pacific.
LEUCOSIIDAE.							
Ebalia malefactrix, sp. nov.	×	..	..	1·000—1·0265	×	×	Backwaters nr. Madras and at Cochin.
Philyra alcocki, sp. nov.	×	..	..	1·000—1·011	×	×	
BRACHYGNATHA							
HYMENOSOMATIDAE.							
Elamena (Trigonoplax) cimex, sp. nov. ..	×	..	..	1·000— ? [1]	..	×	
OCYPODIDAE.							
Ocypoda macrocera, Milne-Edwards ..	×	..	..	1·000—1·0265	..	×	Bay of Bengal; G. of Siam.
,, *platytarsis*, Milne-Edwards ..	×	..	..	1·000—1·0265	..	×	Coasts of Peninsular India; Ceylon.
Gelasimus annulipes, Latreille	..	×	..	1·0265	..	×	Indo-pacific.
Dotilla pertinax, sp. nov.	×	..	..	1·000—1·0265	..	×	
,, *clepsydrodactylus*, Alcock	..	..	×	1·0265	..	×	Coast of Orissa; ? Madras.
,, *myctiroides*, Milne-Edwards ..	..	..	×	1·0265	..	×	Indo-pacific.
Macrophthalmus gastrodes, sp. nov. ..	×	..	..	1·000—1·0265	..	×	
GRAPSIDAE.							
Pachygrapsus propinquus, de Man ..	×	..	..	1·000—1·0265	×	×	Gangetic delta; backwaters nr. Madras.
Varuna litterata (Fabricius)	×	..	..	1·000—1·0265	×	×	Indo-pacific.
Ptychognathus onyx, Alcock	×	..	..	1·000—1·0125 [1]	..	×	? Tavoy.
Camptandrium sexdentatum, Stimpson ..	×	..	..	1·000— ? [1]	..	×	Hongkong; backwaters nr. Madras.
Sesarma tetragonum (Fabricius)	..	..	×	1·0265	..	×	Indo-pacific.
,, *bataviсum*, Moreira	×	..	..	1·000—1·0265	..	×	Backwaters nr. Madras; Batavia.
Plagusia depressa tuberculata, Lamarck ..	..	..	×	1·0265	..	×	Indo-pacific.
GEOCARCINIDAE.							
Cardiosoma carnifex (Herbst)	×	..	..	1·000—1·0265	..	×	Indo-pacific.
XANTHIDAE.							
Heteropanope indica, de Man	×	..	..	1·000—1·0265	..	×	Mergui Archipelago.
Leipocten sordidulum, gen. et sp. nov. ..	×	..	..	1·000—1·0265	..	×	Backwaters nr. Madras.
PORTUNIDAE.							
Scylla serrata (Forskål)	×	..	..	1·000—1·0265	×	×	Indo-pacific.
Neptunus pelagicus (Linnaeus)	×	..	..	1·000—1·0265	×	×	Indo-pacific.
Thalamita crenata (Latreille)	×	..	..	1·000—1·0265	..	×	Indo-pacific.

PAGURIDEA							
PAGURIDAE.							
Clibanarius padavensis, de Man	X	..	..	1·000—1·0265	X	X	W. India to New Caledonia.
,, *longitarsis* (de Haan).. ..	X	..	..	1·0065	X	..	Indo-pacific.
,, *olivaceus*, Henderson.. ..	X	..	.	1·0065—1·010	X	..	Backwaters nr. Madras.
Diogenes avarus, Heller	X	..	..	1·000—1·0265	X	X	E. Africa to Torres Strs.; ? Mediterranean.
COENOBITIDAE.							
Coenobita rugosus, Milne-Edwards ..	..	..	X	1·000— ?[1]	..	X	W. Africa; Indo-pacific; W. America.
,, *cavipes*, Stimpson	..	..	X	1·000—1·0265	..	X	Indo-pacific.
THALASSINIDEA							
CALLIANASSIDAE.							
Callianassa (Callichirus) maxima, A. M.-Edw.	X	..	..	1·000—1·008	X	X	Madras; Siam (sub-fossil).
Upogebia (Upogebia) heterocheir, sp. nov.	X	..	..	1·000—1·0265	X	X	
NATANTIA							
CARIDEA							
CRANGONIDAE.							
Pontophilus hendersoni, sp. nov.	..	..	X	1·0265	..	X	
PALAEMONIDAE.							
Palaemon lamarrei, Milne-Edwards ..	..	X	..	1·007—1·011	X	..	Gangetic delta; Madras.
,, *malcolmsoni*, Milne-Edwards ..	..	X	..	1·000	X	..	Gangetic delta; S. India.
,, *rudis*, Heller	..	X	..	1·000—1·002	X	X	India; Madagascar; E. Africa.
,, *scabriculus*, Heller	..	..	X	1·011	X	..	India to Celebes.
Leander styliferus (Milne-Edwards) ..	..	..	X	1·0265	..	X	Gangetic delta; Burma; Karachi.
Urocaris indica, sp. nov.	X	..	..	1·000—1·0265	X	X	Backwaters nr. Madras; G. of Manaar.
Periclimenes demani, sp. nov.	X	..	..	1·000—1·0265	..	X	Backwaters nr. Madras.
ALPHEIDAE.							
Ogyrides striaticauda, sp. nov.	X	..	..	1·000—1·0265	..	X	Backwaters nr. Madras and at Cochin.
Athanas polymorphus, sp. nov.	X	..	..	1·000—1·0265	..	X	Port Blair, Andamans.
Alpheus crassimanus, Heller	X	..	..	1·000—1·0265	X	X	Red Sea to Celebes.
,, *malabaricus*, Fabricius	X	..	..	1·000—1·0265	..	X	Backwaters nr. Madras; Pt. Blair, Andamans.
,, *paludicola*, sp. nov.	X	..	..	1·000—1·0265	X	X	
ATYIDAE.							
Caridina nilotica var. *bengalensis*, de Man	X	..	..	1·000—1·0265	X	X	Gangetic delta to Ceylon; ? Celebes.
,, *propinqua*, de Man	X	.	.	1·000—1·015	X	X	Northern end of Bay of Bengal.
PASIPHAEIDAE.							
Leptochela aculeocaudata, Paulson ..	..	..	X	1·0265	..	X	Red Sea.
PENAEIDEA							
PENAEIDAE.							
Penaeus carinatus, Dana	X	..	..	1·000—1·0265	X	X	Karachi to Japan.
,, *indicus*, Milne-Edwards	X	..	..	1·000—1·0265	X	X	Red Sea and E. Africa to China.
Penaeopsis monoceros (Fabricius).. ..	X	..	..	1·000—1·0265	X	X	Indus delta to Japan; ? Australia.
,, *affinis* (Milne-Edwards) ..	X	..	..	1·008—1·011	X	?	Indus delta to Japan.
,, *dobsoni* (Miers)	X	..	..	1·000—1·0265	X	X	Coasts of India; Makassar.
SERGESTIDAE.							
Lucifer hanseni, Nobili	X	..	..	1·000—1·0265	X	X	Red Sea; Bay of Bengal.

[1] Probably 1·000—1·0265.

locality a small colony of *Dotilla clepsydrodactylus* was found. In the same month, in other parts of the outer channel, a few immature specimens of *Matuta victor* and single examples of *Dotilla myctiroides*, *Sesarma tetragonum*, *Plagusia depressa tuberculata*, *Leander styliferus* and *Leptochela aculeocaudata* were obtained. Although special efforts were made, these species were not to be found later in the year when the water was fresh and, from the evidence we are able to offer, it appears that they are merely visitors, either brought by chance into the position in which they were found, or seeking shelter from the breakers on the coast-line in the still waters at the mouth of the lake. They are unable to withstand the great alterations in salinity to which the outer channel is subject and in the flood-season must either retire to the sea or perish.

There is evidence that the two species of the almost terrestrial genus *Coenobita*, found in the outer channel, had migrated from the sea-shore, for some of our specimens were inhabiting marine shells not found in a living condition in the lake. The great majority of the specimens were very small and no ovigerous females were obtained. We regard these species also as casual visitors.

The great majority of the casual visitors from the sea are species of wide Indo-pacific distribution.

Palaemon scabriculus, of which two specimens were obtained in brackish water at the mouth of a small stream running into Rambha Bay, is apparently a casual visitor from fresh water.[1]

Although our knowledge of other bodies of water of low or variable salinity on the Indian coast is still meagre, it is possible to institute some comparison between the Decapod fauna of the Chilka Lake and that of the Gangetic delta and of the backwaters near Madras.

The following species, permanent inhabitants of the Chilka Lake, are also known from brackish water in the Gangetic delta, to the Crustacea of which the late Mr. J. Wood-Mason and Col. Alcock devoted much attention:—

Pachygrapsus propinquus.	*Clibanarius padavensis.*
Varuna litterata.	*Penaeus carinatus.*
Scylla serrata.	*Penaeus indicus.*
Neptunus pelagicus.	*Penaeopsis monoceros.*

Metaplax and *Hymenicus*, genera which are plentiful in the Gangetic delta, do not occur in the lake.

A far larger number of species are common to the Chilka Lake and to the backwaters near Madras. Our knowledge of the Decapod fauna of the latter is due to the researches of Dr. J. R. Henderson and to the collections recently made by Dr. Annandale at Ennur:—

[1] A Potamonid crab, *Paratelphusa* (*Oziotelphusa*) *hydrodromus* (Herbst), is common in rice-fields, streams and artificial ponds in the surrounding country. Though we have never found it in the lake itself, it may occasionally wander there in the flood-season.

Ebalia malefactrix.	*Scylla serrata.*
Ocypoda macrocera.	*Clibanarius padavensis.*
Gelasimus annulipes.	*Clibanarius longitarsis.*
Pachygrapsus propinquus.	*Clibanarius olivaceus.*
Varuna litterata.	*Diogenes avarus.*
Camptandrium sexdentatum.	*Urocaris indica.*
Sesarma batavicum.	*Periclimenes demani.*
Cardiosoma carnifex.	*Ogyrides striaticauda.*
Heteropanope indica.	*Alpheus malabaricus.*
Leipocten sordidulum.	*Penaeus carinatus.*
Penaeopsis dobsoni.	

Metasesarma rousseauxi, *Sesarma quadratum* and *Neptunus sanguinolentus*, common and characteristic species in the Madras backwaters, are absent from the Chilka Lake.

It is noteworthy that a considerable number of the species in the above list are known only from Indian backwaters, whereas the majority of those common to the Chilka Lake and the Gangetic delta are widely distributed forms. *Ebalia malefactrix* and *Ogyrides striaticauda* have also been found in the Cochin backwaters on the south-west coast of India.

As far as the Decapods are concerned, therefore, the lake fauna shows a much greater resemblance to that of the Madras backwaters than to that of the Gangetic delta, and this fact is also illustrated by other groups of animals.

Owing to the fact that our survey of the lake fauna was, in the main, restricted to one year, our observations on the periods at which the different species breed are unfortunately very incomplete; but in a few instances the evidence is interesting. On the Indian coasts in February and March females of the great majority of littoral marine Decapoda are to be found bearing eggs and, inasmuch as the water of the lake is at this period almost at its maximum salinity, it would naturally be supposed that species usually marine, or closely related to marine forms, would breed at this season. In several instances, however, this is certainly not the case.

Only of five species (all of them forms found in the outer channel, but absent from the main area) were ovigerous females obtained solely in water as salt as that of the Bay of Bengal (sp. gr. 1 0265). These are:—

Dotilla pertinax.	*Ogyrides striaticauda.*
Diogenes avarus.	*Athanas dimorphus.*
Alpheus malabaricus.	

As far as our observations go, seven species breed in water that is strongly saline or brackish, but were not found bearing eggs in fresh water. The names of these species are as follows, the specific gravities of the water in which ovigerous females were found being added in brackets:—

Pachygrapsus propinquus (1·0075—1·00975). *Upogebia heterocheir* (1·001—1·0125).
Heteropanope indica (1·012—1·0265). *Clibanarius padavensis* (1·010—1·0265).
Leipocten sordidulum (1·0125). *Palaemon lamarrei* (1·007—1·011).
Urocaris indica (1·006—1·0265).

Two species were found bearing eggs both in fresh water and in water as salt as the Bay of Bengal in the vicinity of the lake (sp. gr. 1·000—1·0265):—

Periclimenes demani. *Alpheus crassimanus.*

Four species appear to breed only in water that is fresh or of low salinity:—

Ebalia malefactrix (1·000—1·011). *Caridina nilotica* (1·000—1·015).
Philyra alcocki (1·000—1·011). *Caridina propinqua* (1·000—1·015).

As has already been remarked, *Palaemon malcolmsoni* and *P. rudis* breed exclusively in fresh water and this is perhaps also true of *Elamena cimex.*

In some species, such as *Urocaris indica*, *Periclimenes demani* and *Alpheus crassimanus*, there are perhaps two distinct breeding seasons, but our observations are not sufficiently numerous for us to be certain that this is the case. The two species of *Caridina* breed in the lake throughout the year, reproduction being, however, inhibited when they are brought in contact with water of high salinity.

Owing to the fact that Penaeids do not carry their eggs attached to the swimmerets, as is the case with other Decapoda, it is more difficult to determine the periods at which reproduction takes place. Several circumstances, however, which will be explained in detail hereafter, point to the conclusion that none of the species of *Penaeus* or *Penaeopsis* breed in the lake. Prawns of these genera apparently enter from the sea at the close of the post-larval stages and return thereto when they are sexually mature. In the case of *Penaeopsis dobsoni* there is evidence which tends to show that the females, having once bred, do not again re-enter the lake.

The fifty-four species of Decapoda found in the Chilka Lake comprise thirty-eight genera. The Paguridea of the lake have been determined by Dr. J. R. Henderson, Superintendent of the Madras Museum, who has published a short paper on the subject in the Records of the Indian Museum, describing as new, one species, *Clibanarius olivaceus.* Of the remaining Decapoda thirteen species and one genus do not appear to have been recognized before, while six other forms are recorded for the first time from Indian waters. With three of the undescribed species I have associated the names of Col. A. Alcock, Dr. J. R. Henderson, and Dr. J. G. de Man, to whom more than to any others we are indebted for our knowledge of the Decapod fauna of India. The species of *Callianassa* is identified with a form hitherto known only from a single claw found in a sub-fossil condition in Siam. *Athanas polymorphus*, sp. nov., is of particular interest in the existence among the males of a well-marked trimorphism.

A complete set of all the species, including the types of those hitherto unknown, is preserved in the collection of the Indian Museum.

The methods employed in the capture of the specimens are detailed in the Introduction to this volume (p. 16); an account of the traps used by the Uriya fishermen will be published later.

Our observations on the salinity of the water are expressed in the form of specific gravities. The instrument employed was calibrated for 15°C., and to this temperature all readings have been reduced.

DECAPODA REPTANTIA

Tribe OXYSTOMATA.

Family CALAPPIDAE.

Genus MATUTA, Fabricius.

Matuta victor, Fabr., Hilgendorf.

1896. *Matuta victor*, Alcock, *Journ. Asiat. Soc. Bengal*, LXV, p. 160.

Six small specimens that appear to belong to this species were found in March 1914, in the outer channel; the carapace of the largest is only 11·5 mm. in length. At the time when they were obtained the water in this part of the lake was as salt as that of the Sea in the vicinity; none were found during September when the outer channel is filled with water which is quite fresh.

The species, which is one of very wide Indo-pacific distribution, is evidently carried into the outer parts of the lake during the inflow of salt water; it should be regarded merely as a visitor to the lake-system and not as a permanent inhabitant.

Family LEUCOSIIDAE.

Genus EBALIA, Leach.

Ebalia malefactrix, sp. nov.

(Plate XII, fig. 1.)

The carapace is polygonal in outline and as broad as, or a little broader than long (plate xii, fig. 1.) The postero-lateral borders are very long and gradually convergent posteriorly and the entire margin is elegantly beaded. The side-walls of the hepatic region form a large independent antero-lateral facet on either side of the carapace, extending beneath the eyes to the base of the antennules. The margin that defines the lower limit of this facet is beaded like the true antero-lateral margin and, in dorsal view, is visible in almost its entire extent; a little behind the middle of its length it protrudes slightly in the form of a large obtusely rounded angle.

The front is finely beaded and nearly straight, with a slight and ill-defined median emargination; in dorsal view the edge of the buccal cavern is visible. The antero-lateral margin in large males is obtusely angled in two places and its junction with the postero-lateral margin is very prominent and sharply rectangular. The postero-lateral margin is sharply angulate in its anterior third (this angle marking the termination of a large granular elevation on either side of the carapace) and, in males and some females, one or two of the marginal beads or tubercles in the posterior third

are enlarged, again breaking the evenness of the contour. The posterior margin is convex in the female; in large males it is tridentate owing to the enlargement of the tubercles in the centre and at the outer angles. The infero-lateral margin of the carapace is defined by a beaded ridge immediately above the bases of the legs and this beading extends posteriorly from side to side across the carapace close to the insertion of the first abdominal somite. There are thus, at the posterior end of the carapace, two transverse rows of beading, the uppermost, which is the continuation of the postero-lateral margins, being tridentate in the male.

The most conspicuous feature of the dorsal surface of the carapace is a prominent ridge, much elevated above the general surface and covered with large close-set tubercles, which roughly takes the form of a "broad-arrow" with the point directed forwards. The point is formed by a tuberculate eminence situated in the median line of the carapace a little in front of its middle point. The haft of the arrow extends directly backwards in the mid-dorsal line and ends on the intestinal region before reaching the posterior margin; the wings reach obliquely outwards and backwards on the branchial region and terminate in a sharp prominence in the anterior third of the postero-lateral margin. The tuberculate elevations on the branchial and intestinal regions are separated by narrow grooves from the central cardiac area.

There is usually a short row of large tubercles extending forwards from the cardiac region on either side of the gastric area, continued with or without a brief interruption as a narrow row of smaller tubercles which reaches the front near the inner limit of each orbit, a short branch diverging on the outer side to the back of the orbit itself. There is also a cluster of large tubercles, more conspicuous in the male than in the female, in the vicinity of the first angulation on the antero-lateral margin of the carapace and short row of four or five large tubercles extending transversely outwards on either side from the granular patch on the intestinal region. The areas between the granular patches are sunken and quite smooth; among the granules themselves a few sparse hairs are to be found.

In females, especially in young individuals, the tuberculation of the carapace is much stronger than in males (*cf.* text-fig. 1*a* and pl. xii, fig. 1).

The eyes are small and the cornea is exposed in dorsal view; the orbit is in open communication with the antennular fossae and there is a well-marked space between the edge of the floor of the orbit and the free edge of the buccal cavern. The antennae are small but distinct.

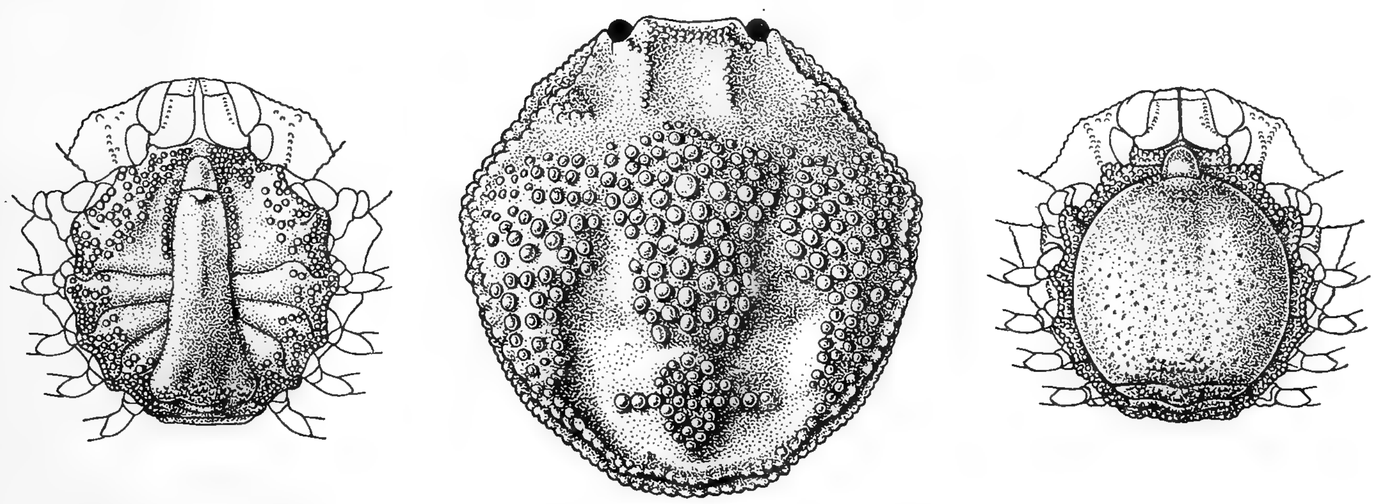
The buccal cavern is a little broader than long. In the external maxillipedes the merus, which is pointed distally, is nearly as long as the ischium and the exopod does not reach so far as the merus of the endopod and is expanded with a convex external margin.

The chelipedes are slightly longer than the carapace in the male, slightly shorter in the female. The merus is more or less cylindrical, covered with vesiculous granules beneath and, dorsally, with granules arranged in parallel rows, a median longitudinal area being left quite naked. The outer edges of the carpus and propodus are very finely granulate and numerous scattered granules are to be seen on the

upper and inner surfaces of the carpus and palm. The palm is scarcely one quarter longer than broad and is not longer than the fingers; near its proximal end on the inner surface there is, in the adult male, a large coarse tubercle. The dactylus of the last pair of walking legs is considerably longer than the propodus.

The margin of the thoracic sternum is festooned with small granules, which also invest the basal parts of the abdomen in both sexes. The abdomen of the male (text-fig. 1*b*) consists of two pieces only, the penultimate portion bearing a large blunt tubercle at its distal end. The fused segments of the female abdomen are coarsely punctured and in the middle line near the distal end there is a small granular patch; the ultimate segment is about as broad as long (text-fig. 1*c*).

Living specimens were, as a rule, rather thickly coated with fine mud. When this was removed they were found to be dull grey in colour, flecked with darker grey, the walking legs and the tubercular elevations of the carapace being reddish-brown.



b. a. c.

FIG. 1.—*Ebalia malefactrix*, sp. nov.

a. Carapace of young female with unusually strong tuberculation.
b. Carapace of male in ventral view.
c. Carapace of female in ventral view.

The largest specimen in the collection is a male, 10·4 mm. in length. The majority of adult examples are from 7 to 9 mm. in length; but one female, only 4·3 mm. long, is fully adult and bears eggs. The smallest individual, about 2 mm. in length, differs in no respect from adults except that the ridges on the carapace are rather more strongly pronounced and the marginal angulations a little sharper.

Ebalia malefactrix appears to be closely related to *E. sagittifera*[1], Alcock, and *E. hypsilon* (Ortmann)[2]. *E. sagittifera*, from Karachi, the types of which I have examined, is a much smaller form and differs in many respects from the Chilka Lake

[1] *E. sagittifera*, Alcock, *Journ. Asiat. Soc. Bengal,* LXV, p. 188 (1896) and *Ill. Zool. 'Investigator'*, *Crust.*, pl. xxix, fig. 9.

[2] *Nursia ypsilon*, Ortmann, in *Semon's Zool. Forschungsreisen Austral. u. Malay Arch., Crust.*, V, p. 36, pl. ii, fig. 7.

species; thus, (i) the margin of the front and orbits is not beaded, (ii) the granular ridges on the carapace, though arrow-shaped, are less strongly elevated and are covered only with minute granules and the other tubercular ridges found in *E. malefactrix* are absent, (iii) the posterior margin bears two tubercles in the female and three large petaloid processes in the male, (iv) the chelipedes and walking-legs are decidedly longer than in the allied species and the fingers in the male are only two-thirds the length of the palm, (v) the apex of the merus of the outer maxillipedes is deeply notched, and (vi) the penultinate segment of the abdomen of the male does not bear a tubercle.

Ebalia hypsilon, found at Thursday I., is perhaps even more closely allied; but in this species, according to Ortmann's figure and description, the ribs on the carapace do not form a connected arrow-shaped ridge. The lateral ribs are Y-shaped and are widely separated from the raised area on the cardiac region which bears three isolated rows of large tubercles. There is a disconnected rounded patch of tubercles on the intestinal region and those found on the anterior part of the carapace in *E. malefactrix* are apparently absent. Moreover the entire upper surface of the carapace bears fine scattered granulations and the pterygostomian ridge is not angulate in the middle.

This species, which was found on twenty-seven occasions, is by no means uncommon in the Chilka Lake. In the main area it does not occur in great abundance, but has been found from Rambha in the south to Nalbano in the north, at depths ranging from a few inches to 8½ ft. In the outer channel it occurs on muddy ground near Satpara and Barhampur I., but is not found on the sandy bottom nearer the mouth of the lake.

Ebalia malefactrix seems to prefer water of low salinity. At the period when the outer channel was at its saltest (in March) it was scarce, but in the same locality in September, when the water was quite fresh, it occurred in abundance. Ovigerous females were caught in the months of March, September and October in water of specific gravity varying from 1·000 to 1·011.

Specimens of this species were found by Mr. Gravely in September 1914, in the backwaters of Cochin, near Ernakulam, and others were obtained by Dr. Annandale in January 1915, in the backwater at Ennur, near Madras (sp. gr. 1·0025). Ovigerous females were caught on both occasions.

The type specimens are registered in the books of the Indian Museum under no. 8941/10.

Genus **PHILYRA**, Leach.

Philyra alcocki, sp. nov.

(Plate XII, fig. 2.)

The carapace is suborbicular and longer than broad in the proportion of 12 to 11. The whole upper surface is microscopically granulate and is covered with rather coarse and distant pits (pl. xii, fig. 2).

The front is somewhat produced, more so than is customary in the genus, and is

narrow; the breadth of the fronto-orbital border is contained about four and one-third times in the maximum breadth of the carapace. The frontal margin is straight, not furrowed, with a single large, median tooth which projects over the otherwise visible margin of the endostome. The dorsal surface of the front is coarsely pitted. The orbit is very small, with distinct dorsal and lateral fissures, and beneath the eye there is a small notch in the margin of the endostome. The orbit is in open communication with the antennular fossae and there is no space between the floor of the orbit and the edge of the buccal cavern.

The side walls of the hepatic region form an independent facet, bounded below by a finely beaded ridge, which is strongly convex inferiorly. This ridge ends in front close beneath the antero-lateral margin at the outer limit of the orbit; posteriorly it joins the antero-lateral margin in a well-marked though obtuse angle. A small prominence defines the junction of the antero- and postero-lateral margins and behind this one or two small projections, the terminations of dorsal rows of tubercles, are visible. The posterior margin is short, straight in the female and concave in the male; the outer angles are strongly marked in the former sex, while in adult males they take the form of two large blunt teeth.

On the upper surface of the carapace the cardio-gastric is separated on either side from the branchial region by a shallow depression and the surface is still further broken by the presence of blunt tubercles which form a definite pattern among the fine granules with which the entire surface is covered. The tubercles are most strongly developed in the adult male, but can readily be seen with the naked eye in both sexes when the surface moisture has been removed. There is, in the first place, a somewhat ill-defined patch of tubercles on the intestinal elevation. In front of this, and not distinctly separated from it, is another similar patch on the cardiac region, which is continued forwards to the gastric region as three ill-defined and widely separated rows of tubercles, the lateral being obsolete in the female. In some specimens the median row is continued as a very fine mid-dorsal carina up to the front.

The tubercles on the branchial region are, as a rule, more distinct than the rest. On either side of the carapace, midway between the middle line and the lateral margin, is a sinuous row of tubercles which curves outwards posteriorly and terminates in the middle of the postero-lateral margin, the junction being often defined by a slight prominence. In front of this row and parallel to its posterior portion is another row of tubercles (less conspicuous in the female) which joins it near its anterior end and is directed obliquely backwards and outwards culminating in a distinct prominence in the anterior third of the postero-lateral margin. This row of tubercles occupies much the same position as the two ridges in *P. olivacea*, Rathbun. Seen in lateral view the figure formed by the tubercles resembles a cursive n.

In the third maxillipedes the length of the merus measured along its inner border is little less than that of the ischium. The flagellum is greatly expanded; its outer edge is strongly convex and the anterior end broadly rounded. The buccal cavern is decidedly broader than long.

The chelipedes in the adult male are one and a half times the length of the carapace, a little shorter in females and young males—about one and a third times. Except for the under surface of the chela the entire chelipede is covered with minute close-set granules similar to those on the carapace. The upper surface of the merus bears three rather obscure rows of small tubercles and the granules on the outer margin of the palm are rather larger than elsewhere. The palm is about one and three quarter times as long as broad; the fingers are about as long as the palm and are grooved and provided with small teeth; when closed, a small proximal gap remains between them. The dactylus of the last leg is about one and a half times as long as the propodus.

In the male the marginal portions of the sternum are finely granulate and deeply pitted. There is a huge longitudinal ridge, abruptly declivous posteriorly, at the base of each chelipede and, in fully adult individuals, there is a very large tubercle on either side of the abdomen opposite the bases of the first walking legs (text-fig. 2).

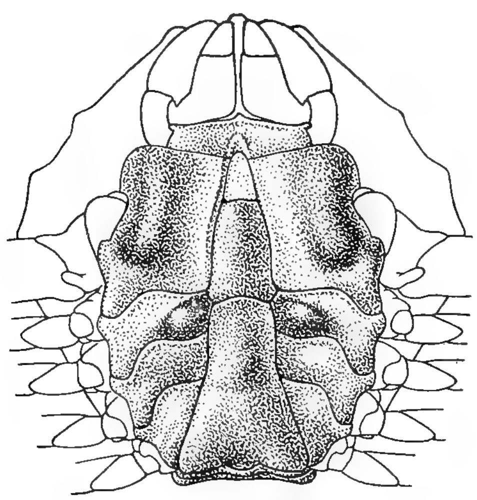


FIG. 2.—*Philyra alcocki*, sp. nov. Carapace of large male, ventral view.

The abdomen of the male consists of three movable pieces and is not granulate. The first segment is acutely produced on either side and, though it appears distinct, is in reality fused to the succeeding piece. The penultimate portion is about one and a third times as long as broad; at its base it is sharply angulate on either side and broader than the distal end of the preceding piece. The ultimate segment is a little less than twice as long as broad. The abdomen of the female is very coarsely and deeply pitted, the ultimate segment being a trifle longer than broad.

The largest specimen, a female, is 13·5 mm. in length. It is only in males measuring 12·5 mm. and upwards that the characteristic sternal tubercles are developed.

In its produced and narrow front, provided with a median tooth that projects beyond the endostome, *P. alcocki* resembles *Pseudophilyra* rather than *Philyra*; but it agrees with the latter genus in the shape of the buccal cavern and of the outer maxillipedes. Laurie, in discussing the characters of *P. adamsi*[1] has already commented on the features in which certain species of *Philyra* resemble *Pseudophilyra*; there is little doubt that the present species, along with that which Laurie examined, may correctly be referred to the *platycheira* section of the former genus.

Philyra alcocki seems to find its nearest ally in *P. olivacea*, Rathbun[2], a species described from Lem Ngob in the Gulf of Siam, but differs from that form in numerous details. In *P. alcocki*, for instance, (i) the carapace is noticeably broader in proportion to its length; (ii) its surface is not so conspicuously granulate; (iii) the rows of

[1] Laurie, *Rep. Pearl Oyster Fisheries, Ceylon*, V, p. 364 (1906).

[2] Rathbun, *Proc. Biol. Soc. Washington*, XXII, p. 108 (1909) and *Danske Vidensk. Selsk. Skrifter* (7), *Naturvid. og math.*, V, p. 312, pl. ii, fig. 17, text-fig. 4 (1910).

granules on either side of the carapace are differently disposed (they form a Λ-shaped figure in *P. olivacea*) and there are distinct angulations at the points when these rows meet the postero-lateral borders; (iv) the posterior margin is bilobate in the adult male (trilobate in *P. olivacea*); (v) there are two pairs of large tubercles on the sternum of the adult male and the margin bordering the anterior part of the abdominal cavity is not granulate; (vi) the palm of the chelae is proportionately more slender and is as long as the fingers; (vii) in the abdomen of the male the penultimate piece is broadest distally, and is at this point sharply angulate on either side.

It also bears some resemblance to *P. sexangula*, Alcock [1], recorded from the Godavari coast and the Persian Gulf and also obtained a few years ago by Dr. J. T. Jenkins in the Matlah river in the Gangetic delta. *P. alcocki* differs, however, from this species in many notable points, (i) in the narrower front and general shape of the carapace, (ii) in the presence of a ∩-shaped pattern of tubercles on either side of the carapace in place of a single oblique ridge, (iii) in the much shorter chelipedes and in the absence of a granular ridge on the upper surface of the palm, and (iv) in the abdomen of the male, which is composed of three instead of two pieces.

From *P. fuliginosa*, Targioni Tozzetti [2], *P. alcocki* is more obviously distinct, differing in its much broader form, in the different arrangement of the granules on the carapace, in the proportions of the chela and in the shape of the abdomen of the male.

In life the colour of the carapace was very pale french grey, with fine speckles of dull purplish-red, aggregated to form irregular sinuous markings. The ventral surface was whitish and the legs a very pale brown.

When caught, specimens adopt a catalyptic attitude, folding their legs and holding them with the ischial and meral segments directed vertically downwards from the carapace (text-figs. 3*a*, *b*). The *Ebalia*, on the other hand, though they kept quite still and also appeared to be simulating death, held their legs normally, with the meral segments tucked up against the carapace.

Philyra alcocki was sometimes found in company with *Ebalia malefactrix*, but appeared to be much less common. It is represented in the collection by sixteen specimens obtained over an area ranging from Rambha in the south to Barkul and Nalbano in the north on a bottom of mud or muddy sand and at depths of from 5 to 10 ft. In September it occurred rarely in the outer channel in fresh water.

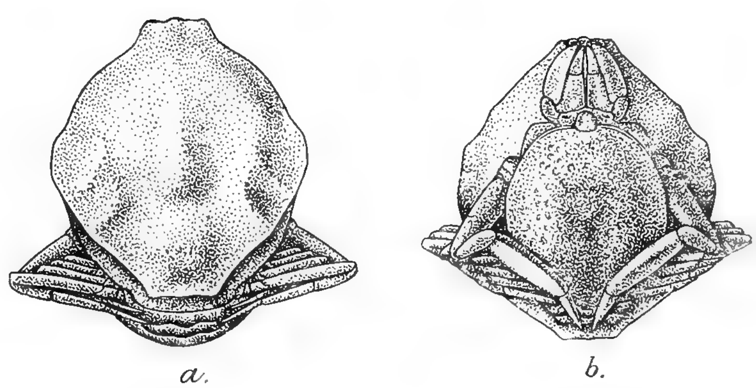


FIG. 3.—*Philyra alcocki*, sp. nov.

A female sketched from life in the attitude which the species adopts when irritated.
a. Dorsal view. *b*. Ventral view.

[1] Alcock, *Journ. Asiat. Soc. Bengal*, LXV, p. 241, pl. vii, fig. 2 (1896).

[2] Targioni Tozzetti, *Zool. Viag. R. P. 'Magenta', Crost.*, p. 201, pl. xii, figs. 3, *a-g* (Florence, 1877).

Two ovigerous females were obtained in the months of March and September in water of specific gravity varying from 1·000—1·011.

The type specimens are registered under no. 8944/10.

Tribe BRACHYGNATHA.

Family HYMENOSOMATIDAE.

Genus **ELAMENA**, Milne-Edwards.

Sub-genus **Trigonoplax**, Milne-Edwards.

1853. *Trigonoplax*, Milne-Edwards, *Ann. Sci. nat. Zool.* (3), XX, p. 224.
1900. *Trigonoplax*, Alcock, *Journ. Asiat. Soc. Bengal*, LXIX, p. 386.

Elamena (Trigonoplax) cimex, sp. nov.

(Plate XII, fig. 3.)

The carapace is flat and lamellar and more or less cordiform in shape; its length, including the front, is a trifle greater than the breadth, the proportion being as 31 to 28. The postero-lateral borders show a slight emargination at the base of each of the last two pairs of legs and are only about half as long as the antero-lateral. The regions of the carapace are defined by shallow grooves, the margin is not upturned, devoid of teeth or tubercles, and except for a few sparse hairs, most noticeable on the hepatic region, the surface is bare (pl. xii, fig. 3).

The front is produced to form a distinct rostrum; it is clearly marked off from the general contour of the carapace and, in the angle formed on either side of its base, the eyes along with portions of the eyestalks are visible. Behind the eye there is a blunt tooth. The rostrum is composed of a single flat plate a little longer than broad; its margins are parallel at the base, narrowing anteriorly to a blunt point.

The antennules are closely juxtaposed at the base; the interantennular septum is wholly missing. The epistome is nearly twice as broad as long. From the anterior angles of the buccal cavern a sharp ridge runs backwards on either side of the carapace to the bases of the walking legs and the surface between this ridge and the true lateral margin of the carapace behind the eye is deeply concave. The external maxillipedes completely close the buccal cavern. The ischium is a trifle longer than the merus and the exopod, though slightly overlapped at the distal end by the adjacent margin of the merus, is nevertheless visible, in part, throughout its length (text-fig. 4).

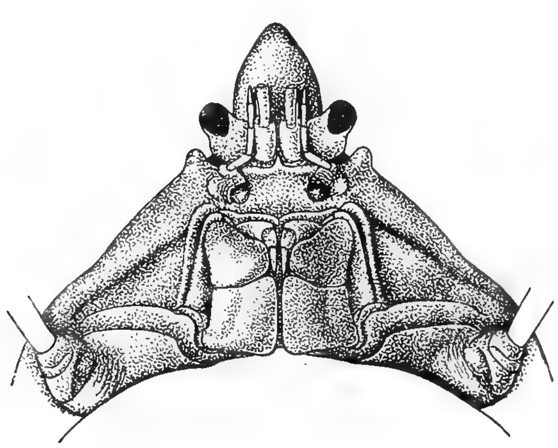


FIG. 4.—*Elamena* (*Trigonoplax*) *cimex*, sp. nov. Anterior part of carapace of a female, seen from below.

Unfortunately no adult males were obtained. In females and young males the chelipedes are slender and, as consideration of the other characters of the species indicate that it belongs to the sub-genus *Trigonoplax* rather than to *Elamena, s.s.*, it may be surmised that they are also slender in the adult male.

In ovigerous females the chelipedes are about as long as the carapace, not stouter and a great deal shorter than any of the walking legs. The carpus is about two-thirds the length of the palm; the fingers are as long as the palm and are curved both horizontally and vertically; when closed, they meet only at the tips which are toothed and slightly spooned. In young males the fingers appear to be a little shorter than the palm.

The first and second pairs of walking legs are about equal in length, nearly two and a half times as long as the carapace, while those of the last pair are the shortest, about one and a half times the length of the carapace. There are no teeth or denticles on the upper margin of any of the segments and the dactyli, which are not broader than the propodi, are set with short hairs, among which, at the distal end, is a series of short recurved teeth (text-fig. 5).

The largest specimen, an ovigerous female, is 7·9 mm. in length.

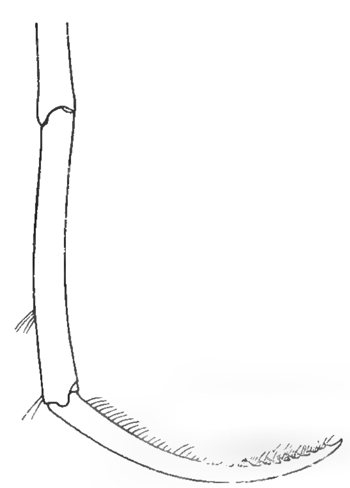


FIG. 5.—*Elamena* (*Trigonoplax*) *cimex*, sp. nov.
Propodus and dactylus of last walking leg.

E. (*Trigonoplax*) *cimex*, though it agrees with *E.* (*Trigonoplax*) *unguiformis*[1], the type and only other known species of the subgenus[2], in many important respects, differs in several notable points, in some of which it bears a significant resemblance to allied genera.

The chief points in which it agrees with typical *Trigonoplax* are (i) the simple—not tridentate—rostrum, (ii) the absence of any teeth or an upturned edge on the margin of the carapace, (iii) the considerable length of the epistome, and (iv) the well-developed external maxillipedes which completely close the buccal cavern.

On the other hand the areolation of the carapace is more distinct than in the other member of the sub-genus; the carapace is proportionately much narrower; there is a distinct post-orbital tooth; the interantennular septum—represented, however, merely by a narrow ridge in *E.* (*Trigonoplax*) *unguiformis*—is wholly absent; the exognath of the outer maxillipedes is not entirely hidden.

In some at least of these characters it shows considerable resemblance to

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[1] De Haan, in Siebold's *Fauna Japonica, Crust.*, p. 75, pl. xxix, fig. 1 (1839); Alcock, *Journ. Asiat. Soc. Bengal*, LXIX, p. 387 (1900); de Man, *Trans. Linn. Soc., Zool.* (2), IX, p. 396 (1907).

[2] Stimpson's *Trigonoplax truncata* [*Proc. Acad. Nat. Sci. Philadelphia*, X, p. 109 (1858) and *Smithson. Misc. Coll.*, XLIX, p. 146 (1907)] is now regarded as a member of *Elamena, s.s.*

Rhynchoplax[1] and to *Hymenicus*[2], the former of which genera, as Alcock has suggested, is perhaps synonymous with the latter. It differs from both, however, in the simple rostrum and, I believe, also in the slender chelae of the male.[3] In addition, it is distinguished from *Hymenicus*, and perhaps also from *Rhynchoplax*, by the well-developed outer maxillipedes which completely occlude the buccal cavern.

In addition to the points mentioned above, *E.* (*Trigonoplax*) *cimex* differs from *E.* (*T.*) *unguiformis* in its narrower form, in the proportionately shorter antero-lateral borders of the carapace, in the shorter legs and in the dactyli, which are slender (not spatulate) and armed with a greater number of spines.

The colouring of living specimens of *E.* (*Trigonoplax*) *cimex* is rather striking. The carapace of an adult female was of a warm reddish-brown tone, tinged with green posteriorly and with a Y-shaped mark of deep umber brown, incompletely circumscribed by cream, extending forwards and inwards on either side from the middle of the lateral margin. The palm of the chelipedes and the distal half of the propodus of all the walking legs was very dark brown, nearly black. The remaining parts of the legs were pale sienna brown.

The carapace, when the animal is walking, is held almost vertically.

The species is represented in our collection by eight specimens, of which, however, only two, which are ovigerous females, are of large size. All were obtained during September 1914, in the outer channel of the lake, chiefly on the weedy and muddy ground in the vicinity of Barhampur I. At the time they were taken the water was quite fresh, but I have no doubt that they are also to be found in the same locality at other times of the year when the water is as salt as that of the Bay of Bengal. The species appeared to be very scarce and it was only with considerable difficulty that specimens could be detected among the weed brought up by the nets.

The type specimens are registered under nos. 8947-8/10.

Family OCYPODIDAE.

Subfamily *OCYPODINAE*.

Genus **OCYPODA**, Fabricius.

Two species of this genus, *Ocypoda macrocera*, Milne-Edwards, and *O. platytarsis*, Milne-Edwards, are found living in the sand at the edge of the outer channel of the Chilka Lake at all seasons of the year. They appear to be equally abundant in this situation both when the water in the channel is fresh and when it is salt.

O. cordimana, Desmarest, a species which has not been found in the lake-system, is common on the seaward side of the sand-hills and may at times wander to the shores of the outer channel.

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[1] *Rhynchoplax*, Stimpson, *Proc. Acad. Nat. Sci. Philadelphia*, X, p. 109 [55] (1858) and *Smithson. Misc. Coll.*, XLIX, p. 147 (1907).

[2] *Hymenicus*, Dana, *Amer. Journ. Sci.* (2), XII, p. 290 (1851) and *U. S. Explor. Exped., Crust.*, I, p. 387 (1852), redefined by Alcock, *Journ. Asiat. Soc. Bengal*, LXIX, p. 387 (1900).

[3] As has already been pointed out, no fully adult males were obtained.

Ocypoda macrocera, H. Milne-Edwards.

1900. *Ocypoda macrocera,* Alcock, *Journ. Asiat. Soc. Bengal,* LXIX, p. 347.

The colouration of adults of this species is very striking. The carapace is of a faint reddish-chestnut colour, greyer in patches and towards the margins, and the cardiac region is defined anteriorly by a semicircular red-brown line. The outer maxillipedes and adjacent portions of the carapace are stained with deep crimson, the sternum being tinged with crimson, dull purple, reddish-yellow and white. The chelipedes are red at the base with red spines and the outer surface of the large claw is bright orange yellow, paler distally. The walking legs are french grey, reddish beneath, with the tips of the claws yellowish. The eyes are greyish-white, with the ocular horn a deep crimson. In immature specimens, about 20 mm. in breadth, there is no trace of red colouration, the carapace being of a dull creamish tint, heavily marbled with dark grey.

For the following interesting notes on the habits of *O. macrocera* in its early stages I am indebted to Dr. Annandale :—

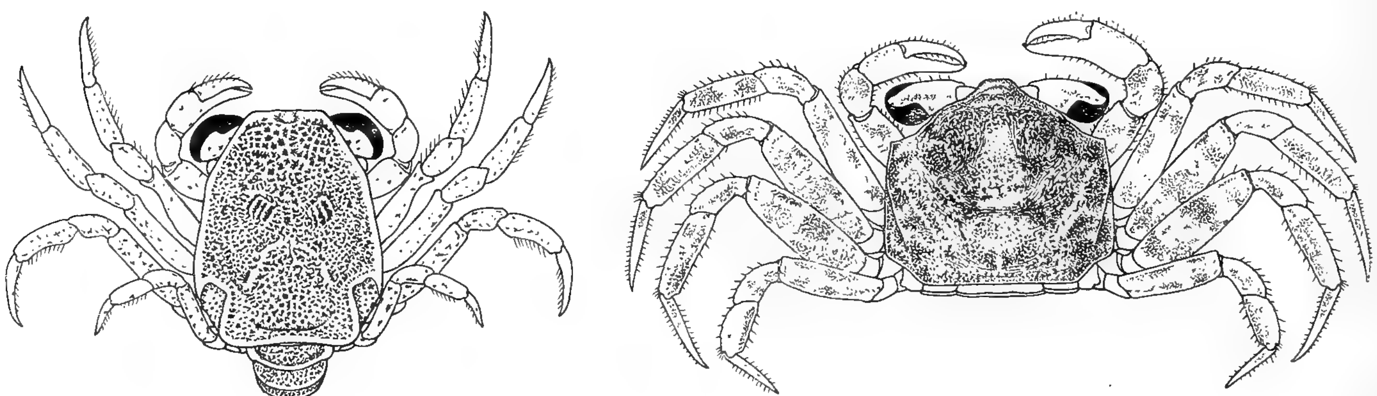
"The young of this species, both in a late megalopa stage and with their skins still soft after the final metamorphosis, were common on the sandy beach of the Ennur backwater, near Madras, in January 1915. They lay in short and imperfectly formed burrows under logs (catamarans), drawn up just above the water-line where the sand was still damp. The megalopae were sluggish and somewhat helpless, but could run along the sand with fair rapidity, their abdomens tucked away beneath the carapace like those of adult crabs. They were easily knocked over, not being at all well-balanced and, when handled or molested in any way, lay still with their legs and tail all pressed together and "shammed dead." Their excavating powers were limited. When one was placed in a dish of wet sand, it turned round and round like a dog, moving its limbs in an unco-ordinated manner, until it had found a small hole in which it remained quiescent. The megalopae were not seen coming out of the water, but there is little doubt that they did so at night, for all those found on the shore were approximately the same size (almost the same as that of the fully formed young crabs), and older members of the same species were observed on several occasions, in the early morning, running towards their burrows with young megalopae in their claws. The larvae exhibited considerable power of colour-change, becoming much paler than usual when submitted to a strong light. Their dorsal surface, when they were in their holes, was of an almost uniform dark leaden grey; when they were placed in a glass vessel it became of a pale glaucous shade."

"The period of the metamorphosis was evidently one of great danger and numerous individuals were observed that had died, both before and after the ecdysis, without apparent injury, probably owing to exhaustion. Allusion has already been made to the cannibal habits of the older crabs of the species, which evidently capture the megalopae and carry them away to be leisurely devoured in their burrows. That they were not merely carrying their young relatives to a place of safety was proved by the fact that one crab was captured carrying the already half-devoured corpse of a megalopa, although in other cases the captives were still uninjured."

"Under the catamarans on the shore a Doryline ant had constructed galleries in the wet sand. These galleries in several cases were noticed to lead to the burrow of a megalopa or newly perfected crab. In such cases the ants were devouring, or had already devoured, the rightful owner, but whether they had waited till its death before doing so, or had attacked it and eaten it alive, could not be ascertained."

"Full-grown crabs of this species are much more retiring in their habits than young and half-grown individuals, which, at any rate in dull weather, may be seen running about the shore, and even in the neighbouring Casuarina woods at all times of the day. The pellets of sand produced in excavating the burrows were merely shovelled out of the holes in a fan-shaped mass and no effort seemed to be made, at any stage in the life-history, to arrange them neatly. In this respect the holes offered a striking contrast to those of *Dotilla intermedia* on the same beach."

The megalopa and first post-larval stage are figured in text-figs. 6*a* and 6*b* from material obtained by Dr. Annandale at Ennur. The megalopa is remarkable for the



a.   *b.*

FIG. 6.—*Ocypoda macrocera*, Milne-Edwards.
a. Last megalopa stage. *b.* First post-larval stage.

presence of deep cavities at the postero-lateral angles of the carapace, into which the last pair of the legs can be folded.

Ocypoda macrocera is common on the sandy shores which fringe the outer channel of the Chilka Lake and also occurs on the adjacent islands. It extends from the mouth of the lake up to Satpara and is found throughout the year, both when the water in the channel is fresh and when it is salt. We failed to find specimens on the neighbouring shores of the Bay of Bengal; but I have little doubt that it occurs there. In the largest specimen obtained, a female, the breadth of the carapace is 32 mm.

The species is known only from the Bay of Bengal and the Gulf of Siam.

Ocypoda platytarsis, H. Milne-Edwards.

1900. *Ocypoda platytarsis*, Alcock, *Journ. Asiat. Soc. Bengal*, LXIX, p. 348.

This species is abundant on the sandy banks of the outer channel near the mouth of the lake. Like *O. macrocera* it is found at all seasons of the year, when the water

is either fresh or salt. It does not, however, extend so far up the channel as the allied species and it has not been found south of Manikpatna. It is common on the adjacent shores of the Bay of Bengal.

The breadth of the carapace in the largest specimen, a male, is 53 mm.

O. platytarsis is known from both coasts of Peninsular India and from Ceylon.

Genus **GELASIMUS**, Latreille.

1897. *Uca* (Leach, not of Latreille), Rathbun, *Proc. Biol. Soc. Washington*, XI, p. 154.
1900. *Gelasimus*, Alcock, *Journ. Asiat. Soc. Bengal*, LXIX, p. 350.

Gelasimus annulipes, Latreille (M.-Edw.)

1900. *Gelasimus annulipes*, Alcock, *Journ. Asiat. Soc. Bengal*, LXIX, p. 353.

The numerous specimens agree well with other examples in the Indian Museum determined by Alcock; the form of the hand in the adult male corresponds very closely with the figure given by Milne-Edwards.[1] The examples are, however, very much smaller than those found in other parts of India, for the breadth of the carapace in the largest male does not exceed 12·5 mm.

Nobili[2] has drawn attention to a difference in the form of the chela in specimens from the eastern and western portions of the Indo-pacific region. To the eastern form he gave the name var. *orientalis*, but subsequently notes[3] that that form is identical with *G. perplexus*, M.-Edw.[4], a name relegated by Hilgendorf and Alcock to the synonymy of *G. annulipes*. Still later, Miss Rathbun[5] recognized *G. perplexus* as a distinct species and gave photographic illustrations of it. The specimens she examined were found at Ceram I. and at Makassar in Celebes, many specimens of typical *G. annulipes* being also found at the latter locality. From the last of these records it is evident that the two forms are not, as Nobili supposed, restricted to separate parts of the Indo-pacific region. But, until further evidence is available, the status of *G. perplexus* must remain doubtful. So far as one is able to judge—for Miss Rathbun gives no description—it is only in the toothing of the large claw of the male that the differential characters are to be found, and in this respect the species of *Gelasimus* often show a wide range of variation. It is only by the examination of long series of specimens from different localities that the point can be determined in a satisfactory manner.

A colony of *Gelasimus annulipes* was found to have established itself in March 1914, on one of the islands in the outer channel of the lake close to Manikpatna. The specimens were living on a narrow strip of land between the water's edge and the coarse grass with which the island was covered. We noticed that the larger individuals occupied the (apparently) more eligible situations close to the water line, while

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[1] Milne-Edwards, *Ann. Sci. nat. Zool.* (3), XVIII, pl. iv, fig. 15*b* (1852).
[2] Nobili, *Boll. Mus. Torino*, XVI, No. 397, p. 13, text-figs. A, B (1901).
[3] Nobili, *Ann. Sci. nat. Zool.* (9), IV, p. 312 (1906).
[4] Milne-Edwards, *Ann. Sci. nat. Zool.* (3), XVIII, p. 150, pl. iv, figs. 18, 18*a* (1852).
[5] Rathbun, *Bull. Mus. Comp. Zool., Harvard*, LII, p. 306, pl. i, figs. 1, 2 (1910).

those that were younger were compelled to live higher up, close to and among the roots of the grass. A detailed and most interesting account of the habits of this and other species of *Gelasimus* has lately been published by Pearse[1], who finds reason to dissent from some of Alcock's views[2] as to the use of the large claw of the male as a means of sexual attraction. In this connection it may be mentioned that large claws of the male, in the rather diminutive specimens found in the Chilka Lake, were for the most part white and showed only the faintest trace of the deep pink colour which characterises well-grown specimens of the species. There was no indication of the bright blue bands which Nobili[3] noticed in certain specimens from S. India.

At the period when the specimens were found, the water in the outer channel was as salt as that of the open sea in the vicinity of the lake. In September of the same year, when it was quite fresh, the colony had entirely disappeared, though whether the individuals were killed off by the fresh water or were induced, by reason of it, to migrate to a more favourable spot remains a matter of conjecture. No specimens of the species were found anywhere in the outer channel in September 1914, though a single example was obtained in the same month of the preceding year on the shore at Satpara; the example may possibly have been brought there by the fishing boats, but this seems unlikely.

The evidence available appears, therefore, to point to the fact that the species is unable to withstand the periodical freshwater floods, and to this conclusion the small dimensions of the specimens also lends colour. Certain other species of amphibious Crustacea found in the outer channel (*Ocypoda*, *Dotilla pertinax* and *Cardiosoma*) seem, on the contrary, in no wise affected by the great changes in salinity.

Subfamily *SCOPIMERINAE*.

Genus **DOTILLA**, Stimpson.

Dotilla pertinax, sp. nov.

(Plate XII, fig. 4.)

The carapace is broader than long in the proportion of 4 to 3 and is strongly areolated and grooved; the grooves are always smooth, while the areolae are for the most part either tubercular or clothed with short stiff setae.

From the front a deep groove runs backwards and bifurcates almost immediately; its two branches are continued obliquely backwards in a straight line to the postero-lateral angles, gradually decreasing in depth towards their distal extremities. Another groove starts in the anterior third of the carapace from each of the branches and runs transversely outwards to the lateral margin; from each transverse groove a short branch runs forwards to the middle of the orbit. In the posterior two-thirds of the carapace, parallel to the lateral margin is a deep and very conspicuous groove, anteriorly bifurcated and Y-shaped (as in *D. malabarica*, *D. sulcata* and *D. fenestrata*),

[1] Pearse, *Philippine Journ. Sci.*, VII, p. 113 (1912).
[2] Alcock, *Ann. Mag. Nat. Hist.* (6), X, p. 415 (1892).
[3] Nobili, *Boll. Mus. Torino*, XVIII, No. 452, p. 20 (1903).

while another groove, faint but distinct, runs transversely close to the posterior margin (pl. xii, fig. 4).

The central triangular region of the carapace, delimited by the two oblique grooves mentioned above, is rather obscurely divided by shallow depressions into post-gastric and cardio-intestinal areolas. The first of these is bluntly elevated anteriorly and the lateral portions of both bear a few coarse and ill-defined tubercles. There is no median longitudinal groove on the anterior part of the post-gastric region. The elevated portions of the carapace behind the orbit also bear tubercles, while those which surround the Y-shaped lateral grooves are finely granulate and set with coarse, stiff setae.

The orbital margin is sinuous and its outer angle, owing to a deep emargination immediately behind it, is prominent and acute in dorsal view. The trough in which the eye lies is continuous beneath this point with a groove which extends along the upper limit of the side-walls of the carapace. The apex of the front is narrowly

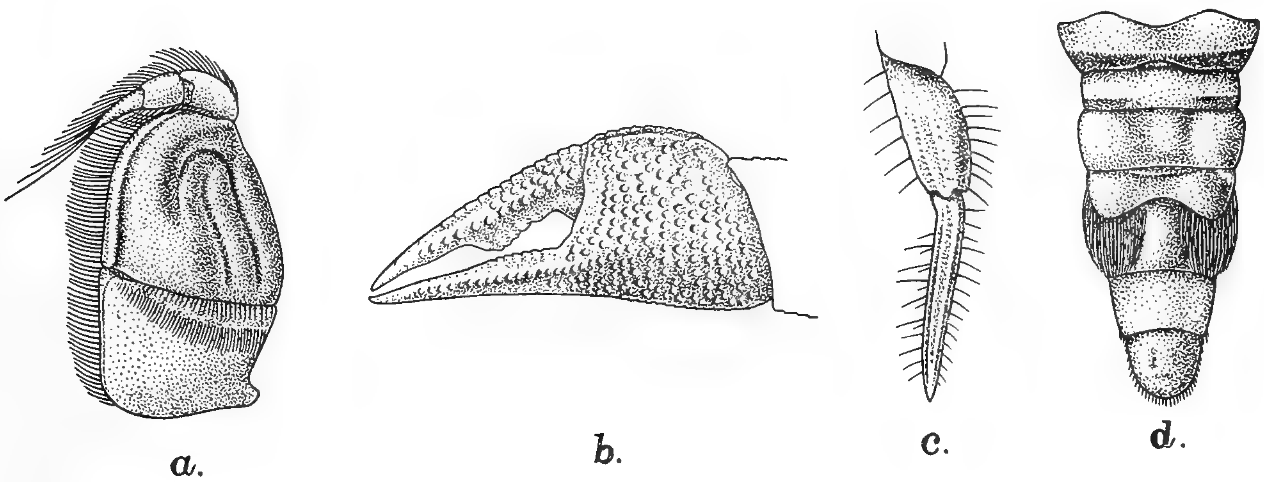

FIG. 7.—*Dotilla pertinax*, sp. nov.

a. Outer maxillipede. *c.* Propodus and dactylus of last leg.
b. Chela of male. *d.* Abdomen of male.

rounded and the subhepatic and pterygostomian regions are finely granular, set with coarse setae, and show the characteristic convolute sulci.

In the external maxillipedes the merus is very much larger than the ischium and is deeply sulcate as shown in text-fig. 7*a*; the grooves cover the greater part of the segment and are not restricted to its outer half as in *D. blanfordi*, *D. intermedia* and *D. wichmanni*. The surface is minutely granulate and bears very short stiff setae.

Measured round the curve, the length of the chelipedes in males that appear to be adult is less than twice the length of the carapace. The spine or tubercle found on the under surface of the merus in *D. sulcata* is absent. The outer surface of the carpus and chela is closely covered with large vesiculous granules (text-fig. 7*b*) which, in some specimens, also invest the inner surface of the palm. On the dorsal edge of the palm the granules are often a little elongated, forming an obscurely defined double ridge; this feature, however, frequently cannot be detected. From the apex of the fixed finger, on its outer side, a granular ridge extends backwards on to the palm,

where it merges with the other granules; the palm is rounded inferiorly and does not bear the fine carinae found in *D. clepsydrodactylus* or *D. malabarica.* The cutting edge of the fixed finger is serrated in its proximal half, but is without teeth. The dactylus, which is about twice the length of the upper border of the palm, bears several rows of granules and its cutting edge, in large males, is produced in the middle to form an angular blade furnished with a few small serrations. When the claw is closed this blade and the extreme tip are the only points in contact with the fixed finger. In females the blade is entirely absent and it is relatively feebly developed in young males.

There is a small "tympanum" on the outer surface of the merus of the chelipedes and a large one on both upper and lower surfaces of this segment in all the walking legs. The merus of the first three walking legs is expanded and the propodus, which is ornamented with longitudinal rows of granules, is scarcely shorter than the dactylus. The dactyli of all the walking legs are conspicuously grooved dorsally, that of the last pair is about one-third longer than the propodus in adults (text-fig. 7*c*), a little longer proportionately in young specimens.

The sternal plates corresponding to the chelipedes are transversely ridged at their *posterior* end[1], the remainder are smooth except for fine scattered granules. There are no sternal "tympana."

The distal end of the fourth abdominal segment is deeply emarginate and bears the usual tuft of thick bristles overhanging the succeeding segment (text-fig. 7*d*). The abdomen of the female is closely similar to that of the male; it is scarcely broader and has the same emarginate fourth segment and the same tuft of bristles. It affords no protection to the eggs, which extrude on either side of it like bunches of grapes. The abdomen of fully adult and ovigerous females consists of seven separate segments, thus differing from de Haan's account of *Doto* (=*Dotilla*) *sulcata*[2].

The carapace of a large male is 5·0 mm. long, 6·4 mm. broad and 4·0 mm. deep. In ovigerous females the breadth of the carapace is only 4·9 mm.

In Alcock's key to the Indian species of *Dotilla*[3], *D. pertinax* would take its place alongside *D clepsydrodactylus*, Alcock, a species which was also found during the survey of the Chilka Lake. From this form it may readily be distinguished by several well-marked characters. In *D. clepsydrodactylus* there is a longitudinal mid-dorsal groove on the carapace and four distinct tubercle-like elevations on the post-gastric region, while the deep groove parallel with the lateral margins is simple and not Y-shaped. There is a large tooth in fully adult males in the middle of the fixed finger and on the lower edge of the chela, which is much more finely granulate externally, there is, even in very small individuals, a well-marked *double* serrated carina. In the legs of the last pair, also, the propodus is much stouter and the dactylus proportionately longer.

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[1] Not in the middle as in *D. clepsydrodactylus.*

[2] De Haan, in Siebold's *Fauna Japonica Crust.*, p. 24 (1833).

[3] Alcock, *Journ. Asiat. Soc. Bengal*, LXIX, p 364.

The configuration of the groove parallel to the lateral margin of the carapace, whether simply linear or Y-shaped, affords a useful character in the discrimination of the species. In this respect *D. pertinax* agrees with *D. malabarica*, Nobili[1]; *D. fenestrata*, Hilgendorf[2]; *D. brevitarsis*, de Man[3]; *D. sulcata*, Forskål[4]; and *D. affinis*, Alcock[5]; and differs from *D. wichmanni*, de Man[6]; *D. intermedia*, de Man[3]; *D. clepsydrodactylus*, Alcock[5]; *D. profuga*, Nobili[7] and *D. myctiroides*, Milne-Edwards[5].

From *D. malabarica D. pertinax* is distinguished (i) by the sculpture of the middle portions of the carapace and by the presence of a faint transverse groove close to the posterior margin, (ii) by the presence of a blade-like tooth on the dactylus of the chela in the male, by the greater comparative length of the fingers and by the absence of carinae on the lower surface of the palm, and (iii) by the presence of a large 'tympanum' on the upper side of the merus of the last legs and by the proportionately shorter dactyli.

Hilgendorf's *D. fenestrata* possesses sternal 'tympana', a character which it shares only with *D. myctiroides*, and the features noticed in Alcock's key suffice to distinguish the present form from *D. brevitarsis*, *D. sulcata* and *D. affinis*. Nobili[7] has drawn attention to the close affinity which exists between the two last named species and, in view of his notes on the variation of *D. sulcata* in the Red Sea, coupled with an examination of specimens of both species (including the types of *D. affinis*) I am inclined to agree with his suggestion that *D. affinis* is merely a synonym of Forskål's *D. sulcata*. In the largest of Alcock's types there is a small tubercle on the lower surface of the merus of the chelipedes in the position which the spine occupies in adult *D. sulcata*.

Living specimens of *Dotilla pertinax* are of a pale sandy brown colour, mottled with black, white, dark brown and orange red. The precise colouring is very variable; there is often a black gastric spot and, in many cases, an orange cardiac blotch. Behind this blotch there is usually a white spot partly surrounded by a brown or black Y-shaped patch, the posterior limb of which extends to the middle of the hinder margin, which is pure white on either side. The furrow at the upper limit of the side walls of the carapace is always deeply pigmented, black, brown or reddish-orange; the sub-hepatic and pterygostomian regions are closely speckled with black and the epistome is often orange red. The legs are banded with brown and white, the carpo-propodal joint of the first two walking legs being orange.

The species constructs burrows in the sand close to the water line; usually the boring is made obliquely and extends to a depth of some six or eight inches. Leading

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[1] Nobili, *Boll. Mus. Torino*, XVIII, No. 452, p. 20, fig. 6 (1903).

[2] Hilgendorf, in van d. Decken's *Reise in Ost-Afrika*, III, p. 85, pl. iii, fig. 5 (1869).

[3] De Man, *Journ. Linn. Soc., Zool.*, XXII, pp 130, 135, pl. ix (1888).

[4] Nobili, *Ann. Sci. nat. Zool.* (9), IV, p. 315 (1906).

[5] Alcock, *Journ. Asiat. Soc. Bengal*, LXIX, pp. 363-368 (1900) and *Illust. Zool. 'Investigator', Crust.*, pl. lxiii, figs. 1-3 (1902).

[6] De Man, in Weber's *Zool. Ergebn. einer Reise in Niederland. Ost-Ind.*, II, p. 308, pl. xviii, fig. 8.

[7] Nobili, *Boll. Mus. Torino*, XVIII, No. 447, p. 22 (1903).

to the mouth of the burrow there is always a well-constructed avenue or "run," two to four inches in length, formed by smoothing the sand and heaping it up on either side. The pellets brought up from the burrow are cast to one side of this "run" and, as a rule, form a triangular patch visible on the smooth surface at a considerable distance. The crabs seem never to wander beyond the limits of the "run."

D. pertinax occurs commonly on the sandy bars and islands in the outer channel and is abundant, both when the water is fresh and when it is salt; it does not in our experience live within a mile of the actual mouth of the lake. The latter region, during the salt-water season in March 1914, was inhabited by a colony of *D. clepsydrodactylus*. The ovigerous females, of which only two were found, were obtained in March. They accompanied other individuals on the shore.

The type specimens are registered under no. 8937/10.

Dotilla clepsydrodactylus, Alcock.

1900. *Dotilla clepsydrodactylus*, Alcock, *Journ. Asiat. Soc. Bengal*, LXIX, p. 367; and *Illust. Zool. 'Investigator'*, *Crust.*, pl. lxiii, figs. 2, 2*a* (1902).

The specimens agree perfectly with the types of the species and with Alcock's account and figures except that the tooth in the middle of the fixed finger is in no case so well developed as is indicated in the original description. Even in individuals in which the carapace is 6 mm. broad, *i.e.* of a size practically identical with that of the largest type specimen, the tooth has merely the form of a low serrated ridge and is only a trifle more prominent than in the preceding species.

In addition to the points mentioned by Alcock it may be noted that the eye is a little flattened and in dorsal view appears almost bilobed, and that there are three finely serrated carinae on the lower surface of the chela, terminating on the fixed finger. Two of these carinae run parallel to one another on the outer aspect of the inferior surface, while the third, situated on the infero-internal border, diverges from them proximally: the lower surface of the palm is in consequence sharply defined, flat and triangular in shape. By the use of this character, coupled with that of the areolation of the carapace (very exactly shown in Alcock's figure) it was easy to distinguish even the smallest specimens of this species from those of *D. pertinax.*

It may ultimately be shown that *D. clepsydrodactylus* is synonymous with *D. intermedia*, de Man, from Sullivan I. in the Mergui Archipelago. I have examined some of the original specimens of the last named species, all of them, unfortunately, small and in rather poor condition. The resemblance to immature *D. clepsydrodactylus* is extremely close, but in the absence of adults from the Mergui Archipelago it is impossible to arrive at any satisfactory conclusion.

Fresh examples of this species were easily distinguished from *D. pertinax* by the absence of the dark speckling on the sub-hepatic and pterygostomian regions.

In March 1914, a colony of *D. clepsydrodactylus* was found to have established itself just inside the mouth of the lake and a stray individual was obtained at the same time in company with *D. pertinax* on the sand-bar opposite Manikpatna. At

this period of the year the water was quite salt. Later, in September, when the water was fresh, no specimens could be discovered.

No species of *Dotilla* were found on the seashore outside the lake. It is not improbable that the violence of the breakers on the coasts of the Bay of Bengal renders such a situation impossible for small and delicate crabs and that they can only flourish in more sheltered spots. *Ocypoda*, perhaps, is able to save itself by its extremely rapid movements.

A number of very small specimens, obtained by Dr. Annandale in the Ennur backwater, near Madras, are also referred to this species. In none of these individuals is there any trace of the large teeth on the fingers of the chelae and the identification is, in consequence, somewhat doubtful.

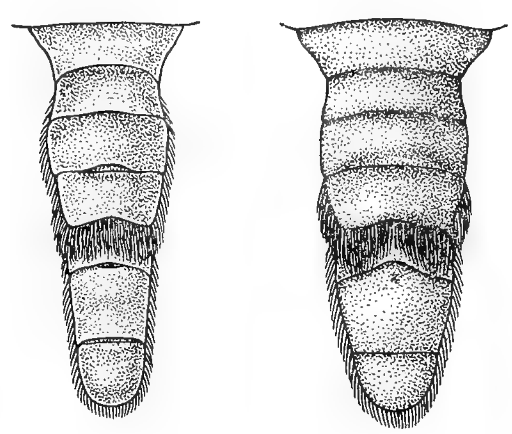
The type specimens of *D. clepsydrodactylus* were found at False Point on the sea face of the Mahanaddi Delta, a locality less than a hundred miles distant in a direct line from the Chilka Lake. Mr. F. H. Gravely has recently obtained a fine series of the species at Balasore, a little to the north of False Point.

Dotilla myctiroides (Milne-Edwards).

1900. *Dotilla myctiroides*, Alcock, *Journ. Asiat. Soc. Bengal*, LXIX, p. 368.

A single example of this species, the carapace 6·9 mm. in breadth, was found on the shore of an island in the outer channel near Manikpatna. The specimen was obtained in March 1914, when the water in the channel was salt.

A large ovigerous individual of this species was recently obtained by Dr. Annandale in the Ennur backwater near Madras. The specimen bears an enormous number of eggs, so many that the abdomen projects backwards in a straight line with the carapace, the masses of eggs bulging out on either side of it and of the legs. In this example, precisely as in the ovigerous females of *D. pertinax* mentioned above, the abdomen is quite narrow and in external appearance closely similar to that of the male (*cf.* text-figs. 8*a* and 8*b*). It is composed of seven separate segments and it seems probable that this number is found in both sexes of all species of the genus and that de Haan was in error in his statement that in females of *D. sulcata* there are only five.



a. *b.*

FIG. 8.—*Dotilla myctiroides* (H. Milne-Edwards).

a. Abdomen of male.
b. Abdomen of female.

The supposed scarcity of females in the genus *Dotilla* has often been the subject of comment; but this, I believe, is to be explained by the close similarity in the form of the abdomen in the two sexes. It is, however, curious that ovigerous females are not more abundant; the eggs, which are poorly protected and must be a great encumbrance to the mother, are perhaps only carried for a very short period and it is noteworthy that the ovigerous specimen of *D. myctiroides* from Ennur was

not taken on the shore, but on the bottom in several feet of water. With the females of *D. pertinax* this was not the case, but it is possible that the eggs in the specimens of this species were freshly extruded.

Subfamily *MACROPHTHALMINAE.*

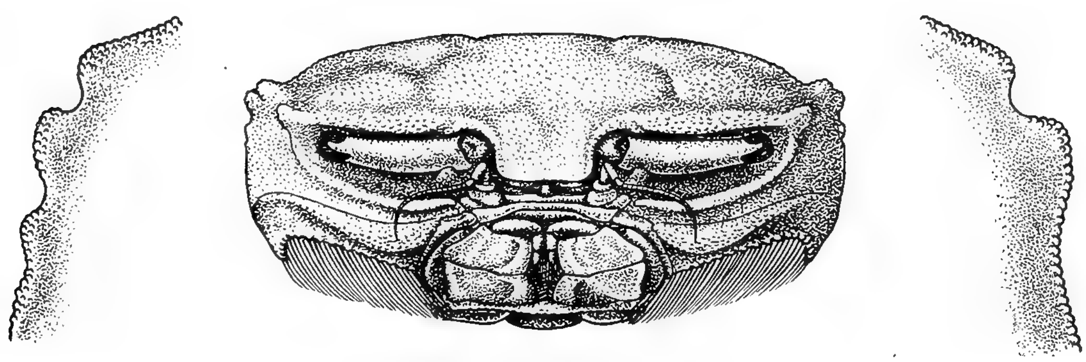
Genus **MACROPHTHALMUS**, Latreille.

Macrophthalmus gastrodes, sp. nov.

(Plate XII, fig. 5.)

The carapace is sub-quadrate, the greatest breadth being only about 1·2 times the greatest length: it is strongly convex both fore and aft and from side to side. The lateral margins are posteriorly divergent, the point of greatest breadth being near the base of the penultimate legs. The breadth across the orbital angles is very little greater than the length (pl. xii, fig. 5).

The front is obliquely deflexed; though longitudinally grooved above, the



a. *c.* *b.*

FIG. 9.—*Macrophthalmus gastrodes*, sp. nov.

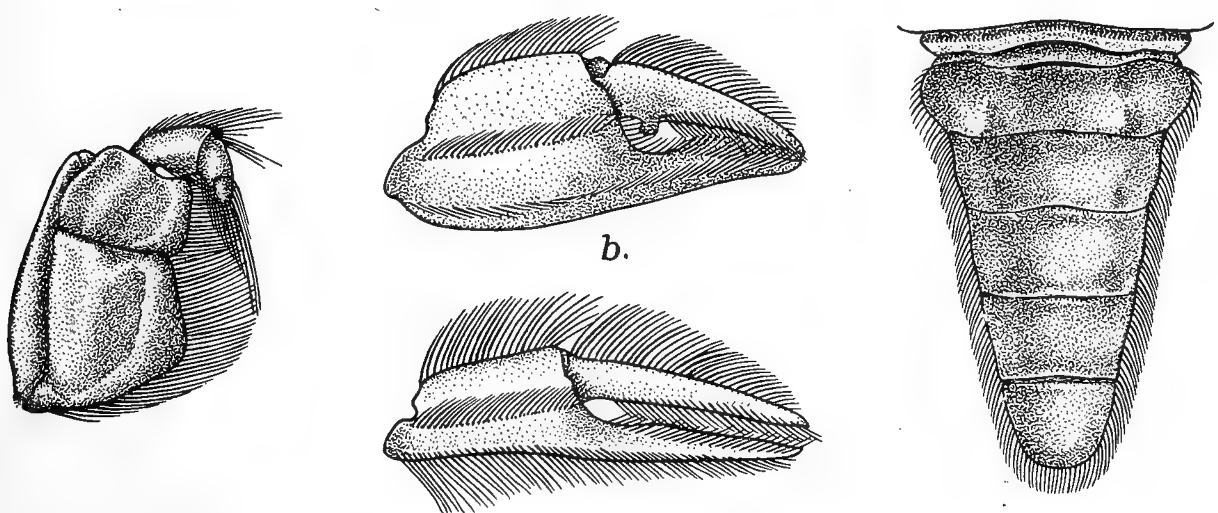
a. Antero-lateral border of carapace of the female specimen, left side.
b. Do. do. do. do. right side.
c. Carapace of the male specimen, viewed from in front.

anterior margin is not bilobed, but is straight or very slightly emarginate in the middle (text-fig. 9*c*). The breadth of the front is about one-sixth the breadth of the carapace at the outer orbital angles, a little wider proportionately in the male than in the female.

The orbits are markedly oblique and rather strongly sinuous. The outer orbital angle is obtuse in both sexes, a little sharper in the male than in the female. Behind it, in the former sex, are three lobular teeth, bluntly rounded and set with small tubercles. The first of these lobes is fully as broad as the outer orbital angle; the second, which is separated from it by a narrow but deep emargination, is much smaller, less than half its breadth; the third is exceedingly indistinct, a scarcely perceptible protrusion of the finely beaded line that marks the margin of the carapace. In the female specimen the antero-lateral borders are not symmetrical. On the left side (text-fig. 9*a*) there are three lobes, similar to those of the male, but less prominent and separated by shallower emarginations. On the right side (text-fig. 9*b*) there is only a single large lobe behind the orbital angle.

The surface of the carapace is strongly areolated, the depressed portions being smooth, while those that are elevated bear granules. The granules are small, very close-set in the male, much sparser in the female. A finely beaded line extends from the posterior lobe of the antero-lateral border round the posterior margin of the carapace. The upper orbital margin is not distinctly beaded, but bears scattered granules similar to those on other parts of the carapace; the lower orbital margin is finely crenulate. From either side of the epistome a blunt ridge, covered with granules, extends backwards to a point above the base of the chelipedes (text-fig. 9*c*). The entire carapace is covered with soft silky hairs, short on the dorsum, longer at the sides and very long beneath the lower orbital margin.

When closed there is a considerable gap between the outer maxillipedes. Both ischium and merus are strongly thickened along their inner margins and both seg-



a. *b*. *c*. *d*.

FIG. 10.—*Macrophthalmus gastrodes*, sp. nov.

a. Outer maxillipede. *c*. Chela of female.
b. Chela of male. *d*. Abdomen of male.

ments show traces of a median longitudinal ridge. The merus is much broader than long and partially overlaps the exopod (text-fig. 10*a*).

The chelipedes of the male are but little longer than the carapace is broad; in the female they are shorter, about equal to the length of the carapace. The merus is slender, without stridulating crest, and without the expanded and crenulate inner margin found in some species of the genus; it bears two rows of long silky hairs. The dorsal surface of the carpus is pubescent; its inner face and the feebly granulate ventral ridge are set with long hairs. In the male the chela is about two and a half times as long as broad (text-fig. 10*b*), the fingers being about one and a half times the length of the upper border of the palm. The inner face of the chela does not bear a tubercle and, except for a strip along its lower edge, is covered by a patch of long hairs that extends to the tips of the fingers. Externally the palm is quite smooth, but is traversed by two impressed lines from which setae arise. The uppermost of these runs longitudinally across the middle of the palmar surface and is

continued on the mobile finger. The other is parallel to it and runs close to the inferior margin, extending to the tip of the immobile finger. Neither the upper nor the lower edges of the palm are granulate. In the middle of the fixed finger, on the inner edge, is a large serrated crest, like a cock's comb, with the distal serrations much larger than the proximal. At the base of the dactylus is a strong molariform tooth. The chela of the female (text-fig. 10*c*) is much more slender, about four times as long as wide, and the fingers are unarmed. It bears rows of setae, similar to those of the male and the surface is covered with a fine pubescence.

The third walking legs are the longest, fully twice the length of the carapace. In all four pairs the upper and lower borders of the meri are granular and on these segments in the first three pairs of the female and the two middle pairs of the male there is on the anterior margin a small sub-terminal spine. The dactyli are flattened and all the segments bear long hairs.

In the male the thoracic sterna bear numerous granules, which also occur, though less abundantly, on the abdomen. In this sex the sutures between the 3rd and 4th and between the 4th and 5th abdominal segments are very fine, the joints being almost immovable, and on either side of these sutures and of that between the 5th and 6th segments there is a large pit or depression (text-fig. 10*d*). The last segment of the abdomen of the female is about one and half times as broad as long.

Only two specimens of this species were obtained; they yield the following measurements (in mm.):—

	♂	♀
Length of carapace	14·8	17·2
Breadth across outer orbital angles	14·9	17·6
Greatest breadth	17·6	20·8
Breadth of front	2·6	2·7

Macrophthalmus gastrodes is apparently allied to *M. serratus*, White[1], from the Philippine Is. and Hongkong, and to *M. definitus*, White[2], which is known from the first of these localities and from Australia. It is easily distinguished from both these forms by many of the characters enumerated above.

In life the species is entirely covered with fine mud; when this was removed the specimens were found to be of an almost uniform clay colour with a purplish-pink flush on the carapace. The scarcity of the species in our collection is perhaps due to the fact that it burrows; in both individuals, however, the cornea is jet-black.

Both specimens were found in the outer channel of the Chilka Lake, on the muddy ground between Satpara and Barhampur I. The male was obtained in March in water as salt as that of the Bay of Bengal in the vicinity of the lake-mouth (sp. gr. 1·0265), while the female was found in September in water that was quite fresh.

The two specimens, types of the species, bear the numbers 9157-8/10 in the Indian Museum Register.

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[1] Adams and White, *Crust. Voy. 'Samarang'*, p. 51 (1848) and Stimpson, *Smithson. Misc. Coll.* XLIX, p. 96, pl xiii, fig. 3 (1907).

[2] Adams and White, *ibid.*, p. 51 (1848) and Ortmann, *Zool. Jahrb., Syst.*, X, p. 342 (1897).

Family GRAPSIDAE.

In addition to purely marine species this family includes numerous forms characteristic of backwaters and estuaries, some aquatic, some amphibious and some almost wholly terrestrial. A considerable number of species are known to exist in water of low salinity and some have succeeded in establishing themselves in fresh water. In the Andaman Is. for instance, *Ptychognathus andamanicus*, Alcock, lives in streams far above tidal influence, while *Sesarma thelxinoë*, de Man, was described from an altitude of 700 ft. In the case of the Andamans, migration from salt to fresh water is perhaps more easily accomplished than in other parts of India, for Potamonidae are entirely absent and the Grapsids are not therefore brought into direct competition with other crabs. As is pointed out on p. 233 the presence of Potamonidae appears to play an important part in hindering *Varuna litterata* from establishing itself in Lower Bengal.

It is remarkable that the genus *Metaplax*, which is abundant in the Gangetic delta and also occurs in backwaters near Madras, is not represented in the fauna of the Chilka Lake.

Subfamily *GRAPSINAE*.

Genus **PACHYGRAPSUS**, Randall.

Pachygrapsus propinquus, de Man.

1908. *Pachygrapsus propinquus*, de Man, *Rec. Ind. Mus.*, II, p. 216, pl. xviii, fig. 2.

Although many of the specimens of this species obtained in the Chilka Lake are very much larger than the types, they do not differ in any marked features from them or from the exhaustive description which de Man has supplied.

The anterior part of the gastric region of the carapace and the frontal lobes are beset with small tubercles which, posteriorly, tend to form transverse ridges much more conspicuous than in the types. Adults resemble the original specimens in having the inner margin of the ischium of the outer maxillipedes quite straight.

The chelipedes in the largest individuals are a little unequal; they are, however, identical in structure. The inner edge of the merus bears three or four blunt tubercles at the base and projects distally as a thin crest bearing three or four teeth that decrease in size as they approach the carpal articulation. The spines at the distal end of the lower margin of the merus of the ambulatory legs vary in number from two to four; the dactyli in all are conspicuously shorter than the propodi. The propodus in the penultimate pair is three and a third times as long as broad, the dactylus being about two-thirds its length.

The largest individual is a female in which the carapace is 23·0 mm. in length and 28·8 mm. in breadth. In the largest male the length is 16·4 mm. and the breadth 20·0 mm.

The colour of the species when alive was striking. The dorsal surface of the carapace was dull olive, boldy mottled with dark purple. The chelipedes were deep violet, shading to orange red on the fingers, while the ambulatory legs were olive

brown with dark purple marginal spots, specially well defined on the propodus. The ventral surface was of a dull olive tone, paler than the back, and the eggs in an ovigerous female were very deep purple, almost black.

Pachygrapsus propinquus is represented in the collection by numerous specimens and appears to be not uncommon at the edge of the lake in those places where a stony foreshore exists. It is a very active species and difficult to catch in numbers; it lives for the most part under stones, but in wet weather may be found running on the shore or on rocks. In the main area of the lake, specimens were obtained in company with *Varuna litterata*, at Barkul, on Barkuda and Cherria Is. and on the rocks at the foot of Ganta Sila. In the outer channel the species was found on three occasions; in March 1914, when the water was as salt as that of the Bay of Bengal, two individuals were obtained clinging to one of the posts that serve to mark the deep water passage near Satpara, and in September and December of the same year specimens were found on the oyster-bed opposite Manikpatna. In September, when the water on the oyster-bed was quite fresh, only a single individual was discovered; but in December, when the water was more saline (sp. gr. 1·0125), numerous young, including specimens in the megalopa stage, were obtained.

The species is common in the Ennur backwater, near Madras, sheltering under blocks of laterite piled up to protect the shore from erosion, and in dull weather running about on these rocks throughout the day.

Ovigerous females found in the lake were obtained at Cherria I. in April and at Barkul in July in water of specific gravity 1·00975 and 1·0075. In the Ennur backwater, near Madras, Dr. Annandale found several ovigerous females in January in water of rather lower density (sp. gr. 1·0025).

The only other known examples of *Pachygrapsus propinquus* are those described by de Man and obtained in brackish pools at Port Canning in the Gangetic delta.

Subfamily *VARUNINAE*.

Genus **VARUNA**, Milne-Edwards.

Varuna litterata (Fabricius).

1900. *Varuna litterata*, Alcock, *Journ. Asiat. Soc. Bengal*, LXIX, p. 401.

This abundant species is not particularly common in the Chilka Lake, though it may be found in some numbers in suitable localities. It seems to prefer a situation close to the water's edge, where some cover, either stones and boulders or the stems and roots of plants, is available. Such amenities are rare on the shores of the lake, the margin of the main area being for the most part bare mud or muddy sand and that of the outer channel muddy sand or sand. At the southern end of the lake, however, more especially on Barkuda, Cherria and Chiriya Is. and at the base of Ganta Sila, the foreshore is stony and in these localities *Varuna litterata* is not uncommon. At the close of the monsoon, when the water is fresh and in many places reaches to the roots of the screw-pines and other vegetation, suitable cover is afforded for a short period and a few specimens were taken in such situations.

The species does not as a rule reach a large size in the lake. The carapace of a female of quite exceptional dimensions is, however, 50 mm. in length. Ovigerous females were not found.

In the Gangetic delta *Varuna litterata* is very much more abundant. Every year at the commencement of the monsoon the waters of the Hughli river in the vicinity of Calcutta teem with young specimens in the megalopa stage. They occur in myriads in all places where the current is sluggish and the water slightly salt and are particularly abundant in the numberless small creeks and backwaters subject to tidal influence. The fact that we never found such larvae during our survey of the lake is strong evidence that the species does not breed there.

It appears that *Varuna* is attempting by two methods to establish itself in fresh water in the neighbourhood of Calcutta and the two modes of invasion may be described respectively as aquatic and terrestrial.

The enormous numbers of young produced in the brackish water are borne, either by their own efforts or by the influence of currents to points where the water is almost or quite fresh, at any rate at certain seasons of the year, and though it appears that the species has not hitherto been able to establish itself in fresh water by this means, the attempt is made annually by countless multitudes. The pipes of the Calcutta unfiltered water-supply have been found completely choked by *Varuna* in its megalopa stage.

The terrestrial method of invasion is adopted by adults. Almost every year the tank (or artificial pond) in the Indian Museum compound, normally inhabited by a Decapod fauna consisting of *Parathelphusa spinigera*, Wood-Mason, *Palaemon carcinus*, Fabr., and *Palaemon lamarrei*, M.-Edw., is visited by stray individuals of the species and large specimens have been seen on the banks vigorously warding off the attacks of crows. To reach this tank the crabs must make their way by night through the streets of the city, probably along the gutters. Specimens have also been found in fresh water in other parts of the delta, but there is no evidence that the species has ever established itself permanently in this medium. That it may eventually succeed in its efforts is not improbable, for a number of Grapsidae are known exclusively from fresh water. In the Gangetic delta the change from salt water is perhaps a minor difficulty; the hordes of Potamonid crabs, which already occupy the desired territory, may prove a more formidable obstacle.

Henderson records the common occurrence of this species at the Ennur backwater, where many other species included in the Chilka fauna are abundant; Dr. Annandale, however, was unable to find specimens there in January 1915.

Alcock[1] notes that *Varuna litterata* is frequently found clinging to logs of driftwood in the open sea, a fact which accounts for its wide distribution. The species is known from an area extending from the east coast of Africa to New Zealand, Australia and Japan.

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[1] Alcock, *A Naturalist in Indian Seas*, London, p. 75 (1902).

Genus PTYCHOGNATHUS, Stimpson.

Ptychognathus onyx, Alcock.

1900. *Ptychognathus onyx*, Alcock, *Journ. Asiat. Soc. Bengal*, LXIX, p. 404, and *Illust. Zool. 'Investigator', Crust.*, pl. lxv, figs. 2, 2*a* (1902).

1905. *Ptychognathus onyx*, de Man, *Proc. Zool. Soc., London*, II, pp. 542-544 (key to species).[1]

This species, hitherto known from two young males "probably from Tavoy", is represented in the Chilka Lake collection by two females and three adult males.

Due allowance being made for age and sex, the examples agree closely with the type specimens and with Alcock's description and figures.

In the adult male, as in the younger type specimens, the exopod of the outer maxillipedes is scarcely broader than the endopod. In the chelipedes there is a dense patch of hair on the lower surface of the merus at its inner and distal ends[2], the carpal spine is very strongly developed and the chelae, which are greatly swollen, are nearly as long as the carapace. The palm is covered externally with microscopic granules, so arranged as to form a reticulate pattern and the surface is rather conspicuously puckered near the point of attachment of the carpus. The fingers are two and a half times the length of the upper border of the palm; though pointed, they are slightly hollowed at the tip and are provided with a series of strong teeth, one of which, near the middle of the fixed finger, is larger than the rest. On the outer surface of the palm a conspicuous and slightly sinuous ridge extends from the base to the tip of the fixed finger and the space between this ridge and the teeth in the finger cleft is occupied by a dense patch of hairs similar to that on the merus (text-fig. 11). The mobile finger is not grooved and does not bear a patch of hair, thus differing from *P. barbatus* (A. Milne-Edwards) and *P. pusillus*, Heller.

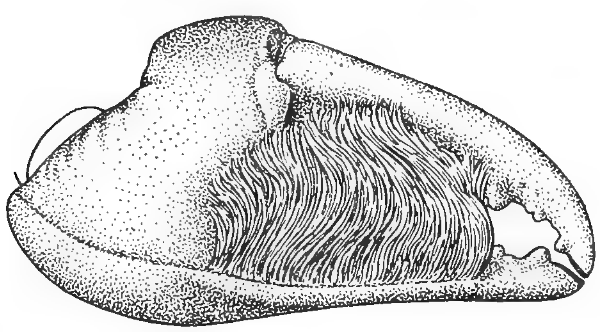


FIG. 11.— *Ptychognathus onyx*, Alcock.
Chela of male, external view.

In the abdomen of the male the penultimate segment is very much broader than the ultimate and its distal angles are sharply and obliquely truncate (text-fig. 12).

Males of this genus are readily determined by the use of the excellent key which de Man has supplied (*op. cit.*). In that which he has given for the identification of females, the present species is omitted, the sex being up till now unknown. Females of *P. onyx* would in this key take place alongside *P. dentata*, de Man, both being separated from *P. riedeli*, A. M.-Edw., and *P. andamanicus*, Alcock[3], by the much

[1] Since this key was published two other species have been described: *P. easterana*, Rathbun, *Mem. Mus. Comp. Zool.*, XXXV, p. 31, pl. ii, fig. 4; pl. vii, figs. 4, 4*a* (1907) and *P. johannae*, Rathbun, *Proc. U. S. Nat. Mus.*, XLVI, p. 354, pl. xxx. The latter species, said to be closely related to *P. riedeli*, is apparently still more closely allied to *P. barbatus* and *P. pusillus*.

[2] This patch is also to be seen in the type specimens, but is not nearly so well developed.

[3] De Man has suggested that *P. andamanicus* and *P. riedeli* are synonymous. I have examined the types of the former species, but have not seen examples of the latter.

less conspicuous toothing of the antero-lateral margin of the carapace, by the presence of distinct epigastric lobes and by the proportionately narrower exopod of the outer maxillipedes.

Females of *P. onyx* bear a very close resemblance to females of *P. dentata*; but in the former the carapace is very much flatter both fore and aft and from side to side, its regions are less pronounced, the frontal margin straighter and the upper border of the orbit much less sinuous. The ischium of the outer maxillipedes is proportionately a little broader and there is only a slight prominence, in place of a tooth, in the middle of the anterior border of the buccal cavern. In females of *P. onyx*, also, the movable finger of the chela is deeply grooved[1], whereas it is almost smooth in *P. dentata*, and, on the outside of the fixed finger, sparse hairs, absent in *P. dentata*, are to be found in the position occupied by the dense furry patch in the other sex.

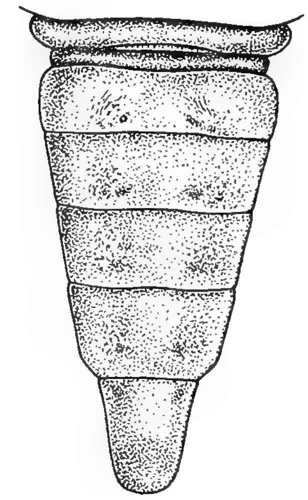


FIG. 12.—*Ptychognathus onyx*, Alcock.

Abdomen of male.

In the largest adult male the length of the carapace is 14·2 mm. and its greatest breadth 15·6 mm., in the two females the lengths are 11·2 and 8·4 mm. and the breadths 12·0 and 8·8 mm., respectively.

The colouration is apparently very variable. The carapace of the male was, in life, of a dull greyish-green tone with pale spots and mottled with darker grey and dull maroon. One female was pale olive yellow and the other dull grey, in both cases with a few obscure dark markings.

Ptychognathus onyx was only found on two occasions in the Chika Lake. Three individuals were taken together in the outer channel on a mud bottom off the village of Mahosa on Barhampur I. in September 1914. The depth was between 6 and 8 ft. and the water at the time of their capture was perfectly fresh. In December of the same year two additional specimens were found on the oyster-bed near Manikpatna in water of sp. gr. 1·0125. The species is evidently very scarce; but is probably to be found in the locality at all seasons of the year, enduring changes of salinity varying from fresh to water as salt as that of the open sea in the vicinity.

As has already been stated, the types and only other known examples of the species were probably obtained at Tavoy on the other side of the Bay of Bengal.

Genus **CAMPTANDRIUM**, Stimpson.

1858. *Camptandrium*, Stimpson, *Proc. Acad. Sci. Philadelphia*, X, p. 106.
1907. *Camptandrium*, Stimpson, *Smithson. Misc. Coll.*, XLIX, p. 137.
1910. *Camptandrium*, Rathbun, *Danske Vidensk. Selsk. Skrifter* (7), *Naturvid. og math.*, V, p. 325.

This genus, hitherto unrecorded from the coast of British India, was originally placed by Stimpson in a separate family; but its affinities are evidently with the

[1] There is a striking difference between the sexes in this respect.

Grapsidae and Miss Rathbun's view that it should be classed with the Varuninae has much to recommend it, though it must be admitted that it is a very aberrant member of the subfamily.

Camptandrium differs from the description of the Varuninae as given by Alcock[1] in having the sub-orbital crest and the lower border of the orbit closely adjacent and in the form of the outer maxillipedes. Only a very small gap remains between these appendages when they are closed and their exopod is slender and partially concealed by the merus. The slender exopod forms a ready means of distingushing the genus from *Varuna, Ptychognathus* and *Pyxidognathus* the only other Indian genera of Varuninae. The hexagonal form of the carapace with its oblique and well-marked antero-lateral margins gives the genus a facies very distinct from that of the more typical representatives of the subfamily, to which, however, it is in some degree linked by Dana's *Cyrtograpsus*.

Camptandrium sexdentatum, Stimpson.

(Plate XII, fig. 6.)

1858. *Camptandrium sexdentatum*, Stimpson, *Proc. Acad. Sci. Philadelphia*, X, p. 107.
1907. *Camptandrium sexdentatum*. Stimpson, *Smithson. Misc. Coll.*, XLIX, p. 138, pl. xvii, fig. 4.

Three specimens of this species were obtained in the outer channel of the Chilka Lake, two young males and a large female, the latter, although dead when brought to the surface and with the carapace detached from the body, being nevertheless in a fair state of preservation. The illustration on pl. xii (fig. 6) is of a young male, the carapace of the female is shown in text-fig. 13.

In most particulars the specimens agree very closely with Stimpson's admirable description; on careful comparison with his account I am only able to detect a few minor discrepancies.

The margin of the front is slightly emarginate in the middle when viewed from above and the dorsal surface of the carapace might more correctly be described as unequal with only two conspicuous transverse interrupted ridges. The surface is finely setose in both sexes and all the more elevated portions bear minute granules. The anterior transverse ridge consists in reality of three largish tubercles, the median of which is interrupted in the middle and is placed at the hinder end of the gastric region. This is clearly shown in Stimpson's figure, in which the more prominent ridge across the cardiac and branchial regions is also exactly indicated. The true infero-lateral margin of the carapace is visible in dorsal view at the base of the last two pairs of legs; the postero-lateral margin is granular and, though convex, is markedly sinuous, while

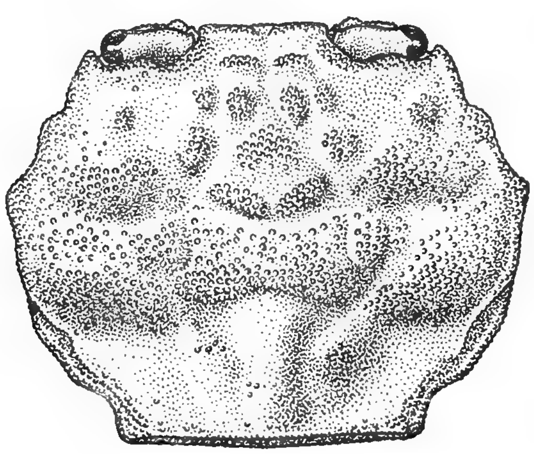


FIG. 13.—*Camptandrium sexdentatum*, Stimpson.

Carapace of female.

[1] Alcock, *Journ. Asiat. Soc. Bengal*, LXIX, pp. 288, 389.

the posterior margin, also granular, is perfectly straight and terminates in a rectangular or acute angle on either side. Of the teeth on the antero-lateral margin the first (which corresponds with the outer orbital angle) and the third are more or less acute; the second is smaller and bluntly rounded. The teeth are sharper in the young males than in the adult female. The upper orbital margin is conspicuously elevated, both at the side of the front and behind the eye, the latter border being strongly sinuous. The lower border of the orbit, as Stimpson has explained, bears a small dentiform lobe internally; the margin is well developed and not deficient as in *Varuna*.

The external maxillipedes are precisely as described by Stimpson. Compared with Miss Rathbun's figure of the appendage in *C. paludicola*, the ischium is more quadrate, equal in length to the merus, and the division between the two segments is straighter and more oblique (text-fig. 14).

The chelipedes in all the specimens are small, weak and shorter than the carapace. The carpus is a little shorter than the palm. The chela is very slender and the fingers are about as long as the palm in the female, a trifle longer in young males. They are slightly curved in dorsal view and are very deeply channelled internally throughout their length, so much so that each resembles a greatly elongated spoon.

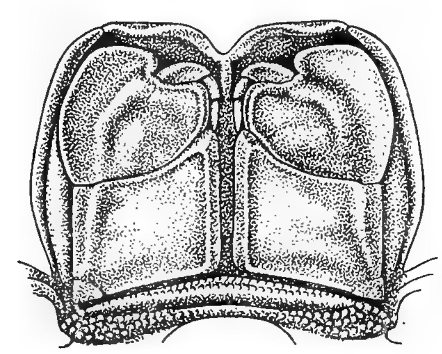


Fig. 14.—*Camptandrium sexdentatum*, Stimpson.

Third maxillipedes of young male.

The first and last walking legs are about equal in length—a little longer than the carapace; the second and third pairs are about one and three quarters the length of the carapace. The merus is more slender than is shown in Stimpson's figure; the ridge near the upper margin is conspicuous and granular. The upper edge is also granular and in young males bears a minute subterminal spinule on the two middle pairs, much smaller than that found in *C. paludicola* and apparently wholly absent in the female. The inferior surface of the merus is provided with two granular longitudinal ridges separated by a comparatively broad interspace. The dactyli are about equal in length with the propodi.

The sternum agrees exactly with Stimpson's description. In the young males the abdomen has a wavy outline, the margin being concave opposite each sternal segment and convex opposite the interspaces of the segments; it could hardly be described as "strongly constricted and sinuated on each side at the middle", but the form is probably subject to change during growth. Except for the most distal one, the sutures between the abdominal segments can scarcely be detected in the larger male example, they are more distinct in the small individual. The sutures in the abdomen of the adult female are conspicuous and markedly sinuous in the middle. The margin of the abdomen is, in this sex, thickly fringed with plumose hairs and, in all the specimens, a number of similar hairs are to be found on the walking legs.

The carapace of the adult female is 7·4 mm. long and 9·4 mm. broad. Its length in the two males is 3·4 mm. and 2·5 mm. The males were, in life, of a dull grey colour, faintly mottled with brown.

The specimens from the Chilka Lake were all found in the outer channel on a muddy bottom, between Satpara and Barhampur I. at a depth of from 1-2 fathoms. At the time they were obtained the water was quite fresh. I have no doubt that they are also to be found in the same locality when the channel is flooded with salt water from the Bay of Bengal; the fact that the species was not met with during March is sufficiently explained by the rarity of its occurrence.

Two minute examples of *Camptandrium sexdentatum* (carapace-length 2·3 mm. and 1·7 mm. respectively) were obtained by Dr. Annandale in the Ennur backwater, near Madras, in January 1915, in water of specific gravity 1·0025.

Stimpson's type specimens are recorded "from a muddy bottom at the depth of six fathoms, in bays of the coast near Hongkong, China."

Subfamily *SESARMINAE.*

Genus **SESARMA**, Say.

Sesarma tetragonum (Fabricius).

1900. *Sesarma tetragonum*, Alcock, *Journ. Asiat. Soc. Bengal*, LXIX, p. 420.

A single example of this species, a male with carapace 29 mm. in length, was found dead on an island in the outer channel near Manikpatna. It was obtained in March 1914, at the time when the water in the channel was salt. The species is, in all probability, only an occasional visitor to the lake-system; it may possibly establish itself for short periods, but of this we have no evidence.

Sesarma tetragonum is a species of very wide Indo-pacific distribution.

Sesarma batavicum, Moreira.

(Plate XII, fig. 7.)

1890. *Sesarma barbimana*, de Man (*nec* Cano), *Notes Leyden Mus.*, XII, p. 104, pl. vi, fig. 13.

1903. *Sesarma batavica*, Moreira (*nom. nov.* for *S. barbimana*, de Man, *nec* Cano[1]), *Arch. Mus. Rio Janeiro*, XII, p. 117. (*fide Zool. Rec.* for 1903.)

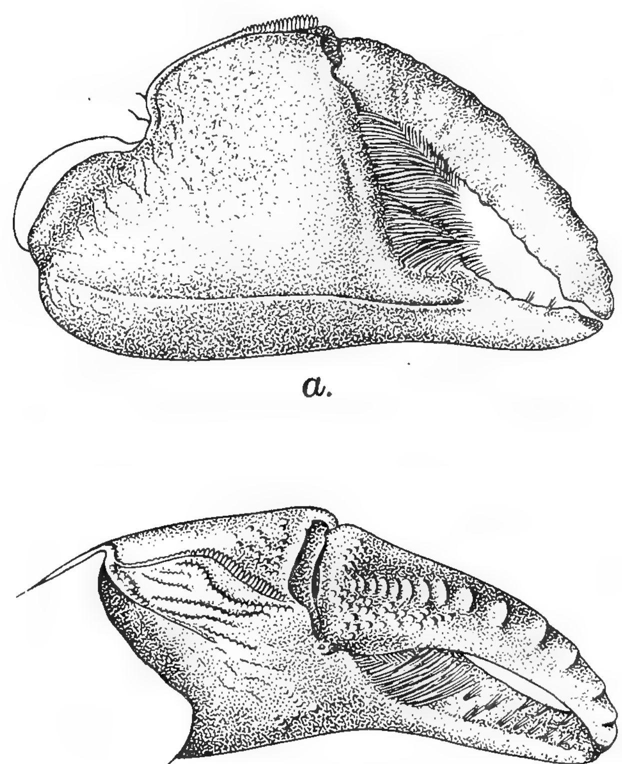
The specimens from the Chilka Lake, though rather smaller than the type, agree closely with de Man's description and figure.

The small transverse rows of setae on the carapace are easily seen and are especially conspicuous in life, for each seta is finely plumose and usually retains a quantity of soft mud. The oblique ridges at the sides of the carapace, as de Man has noted, are very similar to those of *S. andersoni*, de Man (the types of which I have examined). The anterior ridge sometimes, but not always, projects a trifle beyond the lateral

[1] Cano, *Boll. Soc. Nat. Napoli*, III, p. 245 (1889).

margin, forming a very rudimentary tooth behind the outer orbital angle. In *S. andersoni* a short ridge is to be found on either side of the carapace strictly transverse in direction and situated close behind the middle of the orbit. Of this in *S. batavicum* there is no trace.

The chelipedes are almost or quite equal. In the largest specimens the ischium bears a small blunt anterior tubercle and, in all, the antero-inferior edge of the merus is produced distally in the form of a thin triangular crest, apically blunt or rounded and anteriorly serrate. The inner angle of the carpus is rectangular; behind it on the postero-internal face of the segment there is, in both sexes, in addition to the short black hairs on the upper surface noticed by de Man, a linear series of very long stiff setae, also black in colour, and a row of similar but shorter setae extends diagonally across the smooth inner face of the merus. The palm of the chela bears on its upper surface the characteristic ridges figured by de Man. In the male the outermost and best developed of these ridges extends in a sinuous line from the inner end of the dactylar articulation to a point close to the mid-dorsal projection of the carpus (text-fig. 15*b*). This ridge is composed of horny tubercles, the anterior of which are very high and upstanding. Inwards of this limiting ridge are several others, also tubercular but for the most part shorter. One of these defines the margin of the hand and, in the space between it and the primary ridge, and more or less parallel with portions of the latter are two or three other ridges and a few odd tubercles. Below the marginal ridge on the upper and inner face of the palm are other less conspicuous rows of tubercles. The precise arrangement of the ridges is somewhat variable; it corresponds comparatively closely with de Man's figure, though one would gather from his description that only two dorsal ridges existed. The tuft of hairs found on the outer surface of the fingers is conspicuous in all males (text-fig. 15*a*), but, owing perhaps to the small size of the specimens, does not occupy such a long area in lateral view as is shown in the original figure. The hairs extend through the base of the finger-cleft and are visible on the inner side. The fingers in other respects agree in the closest manner with de Man's description, but possess more teeth, often as many as six, on their cutting edges.



a.

b.

FIG. 15.—*Sesarma batavicum*, Moreira.

a. Right chela of male, external view.

b. Left chela of male, viewed obliquely from above.

The chela of the female bears on the upper surface ridges closely comparable to those of the male; there are, however, only a few sparse hairs at the base of the

finger-cleft and the upper edge of the dactylus is quite smooth, showing no indication of the transverse ridges or tubercles possessed by the male.

The ambulatory legs are a little shorter and broader than in *S. andersoni*, but are much more hairy than in that species; in particular the anterior borders of the carpi and propodi are covered with a dense coating of coarse setae of varying length. The meral segments bear a small tooth at the distal end of their anterior margin and a group of two or three teeth in a similar position on the posterior margin [1].

The abdomen of the male is decidedly narrower than in *S. andersoni.*

The length of the carapace in the largest specimen from the Chilka Lake, a male, is 7·5 mm. and its breadth 9·6 mm.

This species, which has not hitherto been found on the coast of British India, belongs to the subgenus *Parasesarma* of de Man's terminology [2] and is one of a small group of five species readily distinguished from the others by the presence of spines on the ambulatory legs at the distal end of the posterior margin of the merus. In 1890 de Man (*loc. cit.*, pp. 97, 98) gave a key to the species of *Parasesarma* then known, three forms belonging to the *andersoni* group being included. Later, in 1909, Calman [3] supplied some valuable notes on the species of the group in his description of *Sesarma murrayi*. *Sesarma batavicum* is readily separated from all its allies by the use of characters derived from the chelae; the arrangement of the ridges on the upper surface of the palm and the presence in the male of a tuft of hairs in the finger-cleft.

Moreira's choice of '*batavica*' as a new name for this form is not a happy one, for de Man, in the same paper that contains his description of *S. barbimana*, has described another species of the genus under the name of *S. bataviana.*

Sesarma batavicum is represented in our collection by many specimens found among the clusters of shells on the oyster-bed in the outer channel opposite Manikpatna. Specimens were obtained on every occasion on which the bed was examined, in March, September and December, both when the water was fresh and when it was as salt as the sea outside the lake. None of the females are ovigerous.

The species is very abundant in the natural cavities of laterite blocks in the Ennur backwater near Madras, where, as in the Chilka Lake, it appears to be entirely aquatic in habits. It was found at Ennur also, amongst clumps of oysters. The specimens are larger than those from the Chilka Lake; the carapace of a male being 8 mm. long and 10·2 mm. in breadth; the collection was made in January 1915, in water of specific gravity 1·0025, and includes a number of ovigerous females.

The only other specimen known is the individual described by de Man and found on the sea-shore at Batavia.

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[1] The teeth found in *Sesarma murrayi* at the *proximal* end of this margin are not present in *S. batavicum*.

[2] De Man, *Notes Leyden Mus.*, XII, p. 97 (1890) and *Zool. Jahrb., Syst.*, IX, p. 181 (1895).

[3] Calman, *Proc. Zool. Soc., London*, p. 709 (1909).

Subfamily *PLAGUSIINAE.*

Genus **PLAGUSIA,** Latreille.

Plagusia depressa (Fabricius), subsp. **tuberculata,** Lamarck.

1900. *Plagusia depressa* var. *squamosa*, Alcock, *Journ. Asiat. Soc. Bengal*, LXIX, p. 437.

1906. *Plagusia depressa* vars. *tuberculata* and *immaculata*, Laurie, *Rep. Pearl Oyster Fisheries, Ceylon*, V, pp. 429, 430.

1906. *Plagusia depressa tuberculata* and *P. immaculata*, Rathbun, *Bull. U.S. Fish Comm. for* 1903, III, pp. 841, 842.

1907. *Plagusia orientalis* and (?) *P. depressa*, Stimpson, *Smithson. Misc. Coll.*, XLIX, p. 122.

1910. *Plagusia tuberculata*, Rathbun, *Proc. U.S. Nat. Mus.*, XXXVIII, p. 590, and footnotes to references by Stimpson (*op. cit.*).

1910. *Plagusia depressa tuberculata*, Rathbun, *Danske Vidensk. Selsk. Skrifter* (7), *Naturvid. og math.*, V, p. 330.

As Laurie and Miss Rathbun have remarked it is probably best, in view of the uncertainty that exists regarding the identity of Herbst's *Cancer squamosus*, to avoid the use of that term as a varietal or sub-specific name. Examination of the specimens in the Indian Museum leads me to believe that Alcock was right in refusing to recognise more than one form of the species in Indian waters. The series shows every possible intergradation between the vars. *tuberculata* and *immaculata* as defined by Laurie.

The only individual obtained in the Chilka Lake is extremely small, the carapace being 7 mm. in length. The tubercles on the dorsal surface are much depressed, but are heavily fringed with setae.

The specimen was obtained in the outer channel in March 1914, at the time when the water was salt. It was found clinging to a pole that served to mark the deep water passage in the vicinity of Satpara. No specimens were observed when the water was fresh and the species is doubtless to be regarded as a casual visitor to the lake-system.

The subspecies *tuberculata*, which is frequently found on floating timber far out at sea, has a very wide Indo-pacific distribution, extending from the Red Sea and East Africa to the western coasts of America from Lower California to Chili.

Family GEOCARCINIDAE.

Genus **CARDIOSOMA,** Latreille.

Cardiosoma carnifex (Herbst).

1900. *Cardiosoma carnifex*, Alcock, *Journ. Asiat. Soc. Bengal*, LXIX, p. 445.

1907. *Cardiosoma carnifex*, Rathbun, *Mem. Mus. Comp. Zool., Harvard*, XXXV, p. 26.

The two specimens found in the Chilka Lake agree closely with other examples in the Indian Museum and differ from *C. hirtipes*, Dana [1], in the characters noted by Alcock and Miss Rathbun. There seems, however, to be some variation in the degree

[1] Miss Rathbun [*Bull. U.S. Fish Comm. for* 1903, pt. 3, p. 838 (1906)] identifies this species with the earlier *Thelphusa rotunda* of Quoy and Gaimard.

of hairiness of the ambulatory legs. In the specimens from the Chilka Lake the hairs are much more numerous than in an individual from the Andamans and occur over almost the entire length of the upper border of the merus.

Miss Rathbun[1] has given a fresh diagnosis of the allied West Indian *C. guanhumi*, Latreille, which leads me to suppose that the species is distinct from *C. carnifex*.

The two specimens are both males and are 61·5 and 62·5 mm. in length and 73·5 and 74 mm. in breadth.

The colour in life is striking. The dorsal surface of the carapace is livid purple with a close and fine reticulation of yellowish-green which gradually disappears towards the sides and is densest in the central part of the cardiac region. The hepatic regions and the sides of the carapace are lilac. The ventral surface is cream-coloured, the epistome tinged with purple. The chelipedes are cream-coloured, deepening to yellow on the palm and fixed finger and suffused on the dorsal surface of the merus and carpus with purple. The extreme tips of the fingers are brown. The basal joints of the walking legs are yellowish; the merus, carpus and propodus are deeply tinged with purple and bear dark brown hairs; the dactylus is orange yellow.

Colonies of this species inhabit the islands in the outer channel near Manikpatna. In March 1914, when the water was low and as salt as that of the sea outside the lake, large burrows of *C. carnifex* were found, their mouths often four or five inches in diameter. Similar burrows were noticed below the surface of the water in the vicinity and, on the shore, fragments of specimens that had been eaten by birds were abundant. In September, when the water in the outer channel was fresh, the species was also in evidence, but on this occasion, owing to the rise in the water-level, most of the burrows were below the surface. The crabs seem to live at a considerable depth in the mud and, as a rule, do not wander by day; it was in consequence difficult to obtain specimens.

Family XANTHIDAE.

Genus **HETEROPANOPE**, Stimpson.

1898. *Heteropanope*, Alcock, *Journ. Asiat. Soc. Bengal*, LXVII, p. 207.
1907. *Heteropanope*, Stimpson, *Smithson. Misc. Coll.*, LXIX, p. 62.

Heteropanope indica, de Man.

1888. *Heteropanope indica*, de Man, *Journ. Linn. Soc.*, XXII, p. 53, pl. iii, figs. 1, 2.
1898. *Heteropanope indica*, Alcock, *Journ. Asiat. Soc. Bengal*, LXVII, p. 208.

I have compared the specimens in the collection with the individual recorded by Alcock, apparently one of the two examples on which de Man based his original description, and find them in perfect agreement.

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[1] Rathbun, *Bull. U. S. Fish Comm. for* 1900, XX, pt. 2, p. 15 (1902).

The larger chelipede of the female, which de Man was unable to examine in the material at his disposal, is as large as that of the adult male; but the carpus, instead of being smooth, is coarsely and irregularly granulate, the granules forming definite rows or groups near the distal margin. The palm also bears definite granules on its upper edge and on the outer surface at the base of the fingers.

The figure given by de Man is a trifle misleading, for the species is represented a little longer and less transverse than it really is and there is only a faint indication of the transverse granular ridge in the vicinity of the third tooth of the antero-lateral margin. This ridge, which is conspicuous in all the specimens, is of some importance, as it is absent in the closely allied species *H. africana*, de Man.[1] In our specimens the chelae are of a uniform dull yellowish or brownish colour, with the fingers black from tip to base; I have not seen any individual in which the colour resembles that shown in de Man's figure.

Heteropanope indica is represented in the collection by twenty specimens. The carapace in the largest example, a male, is 15·2 mm. in length and 22·2 mm. in breadth. In ovigerous females the carapace varies from 9·6 to 14·4 mm. in length.

With the exception of a single individual found on a post, placed to mark the position of the deep water passage near Satpara, all the specimens were obtained on the oyster-bed in the vicinity of Manikpatna. They were found living in the dead and gaping shells and in the chinks and crannies between them and were obtained both when the water was fresh and when it was as salt as the Bay of Bengal near the mouth of the lake. The ovigerous females were taken in the months of March and December.

A single specimen was taken by Dr. Annandale in the Ennur backwater, near Madras, in January 1915, also among oysters.

The species was hitherto known only from the two type specimens, obtained in the Mergui Archipelago.

Genus LEIPOCTEN, nov.

Carapace but little broader than long, subquadrilateral, slightly convex both fore and aft and from side to side, not or scarcely areolated, sparsely tuberculate and densely tomentose. Antero-lateral borders entire except for isolated tubercles, or cut into one or two blunt crenulate lobes in addition to outer orbital angles. Postero-lateral borders very short.

Front rather less than a third the greatest breadth of carapace, slightly deflexed, not notched in the middle line; the lateral angles prominent in a facial view.

Fronto-orbital border four-fifths the breadth of carapace. Orbits large, without fissures or sutures. Basal antennal segment short and broad, its inner angle touching the front, the flagellum standing in the orbit.

Antennular region and epistome very short in a fore and aft direction; the latter almost obliterated, especially in the middle where the front almost touches the strongly rounded anterior margin of the buccal cavern. Crests of endostome, defining the

[1] De Man, *Bull. Mus. d'Hist. nat. Paris*, VIII, p. 244, text-figs. 1, 2 (1902).

expiratory channels, not very strong but continued to anterior margin. Buccal cavern broader than long; its lateral borders on either side defined by two conspicuous ridges enclosing a deep trough.

External maxillipedes large. Ischium and merus smooth, the former quadrate with concave anterior (sutural) border. Merus about as long as broad, larger than ischium; inner margin strongly curved, outer margin partially overlapping exopod, anterior margin with a small process external to insertion of palp.

Chelipedes equal in both sexes, much larger in the male than in the female. Palm of chela in female sharply spinulose, fingers without teeth internally. Chela of male swollen, for the most part smooth; inner margin of dactylus with one great tooth at proximal end; tips of fingers not spooned. Walking legs short and stout, meral segments somewhat dilated with large spinous tubercles arranged, as seen from below, in a U-shaped figure. Legs shaggy.

Abdomen of male composed of six segments, the first four, though with distinct sutures, apparently forming a single immovable piece.

Type,—*Leipocten sordidulum*, sp. nov.

The affinities of this genus are obscure. The complete character of the endostomial ridges indicates a position in the section Hyperomerista and of the subfamilies that Alcock includes in this section it agrees more nearly with the Eriphiinae than with any other. From the Eriphiinae it differs in the narrower front and shorter postero-lateral borders, in the form of the outer maxillipedes, in the presence of a double keel on either side of the buccal cavern and in the peculiar spinulation of the walking legs. It clearly cannot be classed with any of the "alliances" of Eriphiinae recognised by Alcock and is perhaps better regarded as the type of a distinct subfamily.

Leipocten sordidulum, sp. nov.

(Plate XII, fig. 9.)

The carapace is subquadrilateral, broader than long in the proportion of 19 or 20 to 15. The antero-lateral borders are subparallel, only a little divergent posteriorly, and are nearly one and half times the length of the postero-lateral. The dorsal surface is slightly convex in both longitudinal and transverse directions—more so in females than in males—and shows only the faintest traces of areolation.

When the dense tomentum is removed, the surface is found to be finely pitted and to bear small pearly grey tubercles, extremely variable in their number and disposition. In some female individuals they are more abundant than in the specimen figured on plate xii, covering the entire surface, in others they are less numerous, while in males they are frequently altogether absent except in the vicinity of the lateral margin. Certain tubercles near the junction of the antero- and postero-lateral borders and a few above the base of the last legs are, as a rule, larger and more conspicuous than the rest.

Even greater variation is shown in the structure of the antero-lateral border. In

the female figured on plate xii, which is extreme in this respect, the margin only bears large scattered tubercles behind the acute orbital angle; in other females and in most males the tubercles are aggregated to form one or two protrusions or lobes which, in some cases, are separated by definite emarginations of the border (text-figs. 17*b*, 17*c*).

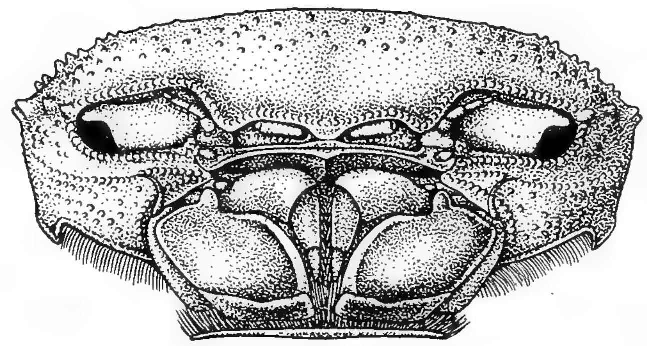
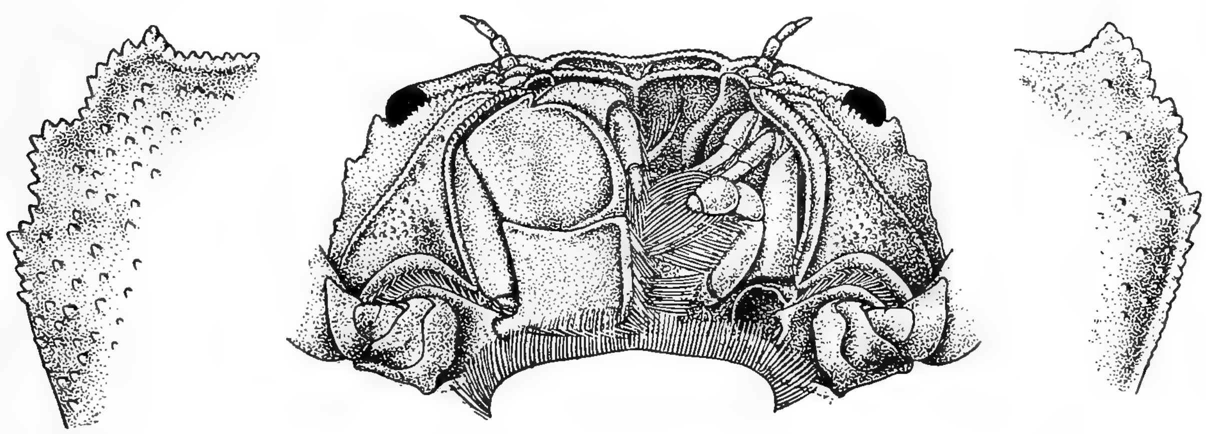


FIG. 16.—*Leipocten sordidulum*, gen. et sp. nov. Carapace of a female, seen from in front.

The front is one-third or a little less than one-third the greatest breadth of the carapace and is only very slightly deflexed. Dorsally it exhibits feeble longitudinal depressions in the middle and near the inner border of each orbit, and there are faint indications of a pair of pre-gastric lobes. The anterior margin is straight in dorsal view; but, seen from in front, it projects downwards in the middle and at the lateral angles (text-fig. 16).

The fronto-orbital border is about three quarters the greatest breadth of the carapace.[1] The upper margin of the orbit is a little sinuous and is sometimes, but not always, obscurely crenulate in part or in all of its course. The inferior margin is evenly curved and crenulate, meeting the upper margin externally without any appreciable gap or emargination. The side-walls of the carapace beneath the antero-



b. *a.* *c.*

FIG. 17.—*Leipocten sordidulum*, gen. et sp. nov.

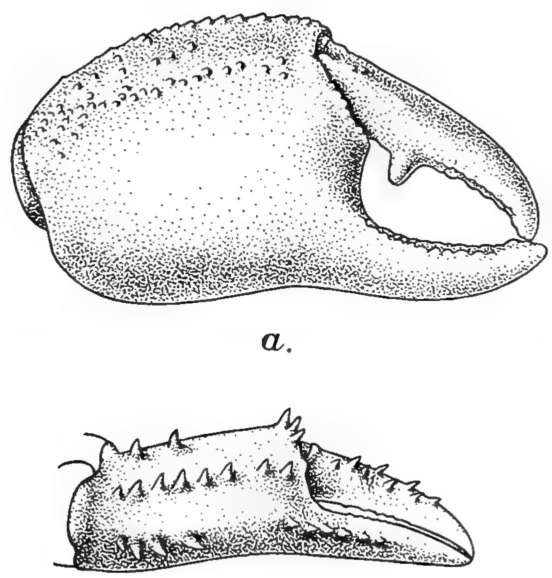
a. Anterior portion of carapace from below, left outer maxillipede removed.
b. Antero-lateral margin of carapace of a female from Madras.
c. *do.* *do.* of a male from Madras.

lateral border are smooth or feebly tuberculate and are traversed by a finely beaded line that extends from the outer angle of the epistome to the enlarged tubercles above the base of the last leg. The true infero-lateral border is also finely beaded. The posterior border is straight in both sexes and about as long as the front; it is traversed by two beaded lines, rather widely separated and continuous with that on the infero-lateral edge.

[1] It varies from 0·65 to 0·8 times the greatest breadth.

The opening of the buccal cavern is transversely oval, widest in the middle. Its lateral border is formed by a pair of sharp ridges, that coalesce both in front and behind and enclose a deep trough formed to receive the outer edge of the exopod of the third maxillipedes (text-fig. 17*a*). The structure of the latter appendages is sufficiently described under the generic heading.

The chelipedes are much larger in the male than in the female, but are symmetrical in both sexes. In the female they are a little shorter, and in the male about a third longer than the breadth of the carapace. The merus is trigonal, with the upper and outer margins serrated and often with a few tubercles beneath; in the male it is about as broad as long. The carpus of the male does not bear a spine at the inner angle; but the inner margins, as seen in dorsal view, are coarsely serrate. In the female the carpus is more elongate; it bears low tubercles or sharp spinules along its inner and distal borders and sometimes a longitudinal row on its upper surface as well. The chelae of the male are greatly enlarged, each is about twice as long as broad (text-fig. 18*a*). Externally the palm is quite smooth, except that near the carpal articulation there is a patch of low granules which are continued in single row almost to the base of the dactylus. The upper border of the palm also bears granules, irregular in their disposition; the inner surface and the lower border are smooth. The fingers are not grooved and are not spooned at the tips; in adults they meet only at the tips. Each finger is provided internally with three rows of low and inconspicuous tubercles and at the base of the dactylus, which is a little longer than the upper border of the palm, there is a huge blunt tooth.



a. *b.*

FIG. 18.—*Leipocten sordidulum*, gen. et sp. nov.

a. Chela of male. *b.* Chela of female. Tomentum not represented in *b.*

The chela of the female is slender and widely different from that of the male (text-fig. 18*b*). It is more than three times as long as wide and the palm, on its upper border and outer surface, bears three or four rows of large spinules, the lowermost being continued on to the fixed finger. The fingers are not armed internally and meet throughout their length when the claw is closed; the dactylus bears small spines and is a trifle shorter than the palm. The chelipedes of the female are densely tomentose, whereas in the male they are almost bare.

The walking legs are short and stout. The upper surface of the merus bears scattered tubercles, sometimes very conspicuous in the female, less well developed as a rule in males; the anterior border is feebly crenulate. On the posterior border and lower surface of the merus are spinules and tubercles, very characteristic in their disposition (text-fig. 19). The posterior border bears a row of spinules of varying size, one or two being as a rule much larger than any of the others. The row

extends back proximally to a point not far from the articulation of the ischium, then turns across the inferior face of the segment in the form of a series of slender teeth with blunt tips and is continued obliquely outwards to the antero-inferior angle of the mero-carpal joint. In the last part of their course the spinules are widely separated and are reduced to small tubercles; but, close to the carpus, they are more closely set and form a finely serrate crest. The spinules are better developed in the female than in the male; seen from below they present a U-shaped figure, the upper extremities of the U being situated on either side of the mero-carpal joint. The carpus and propodus are short and swollen and bear a few blunt teeth distally. The dactylus is conical and slightly curved.

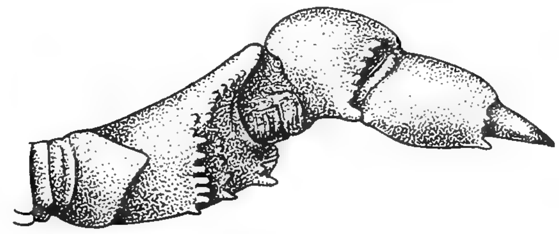


FIG. 19.—*Leipocten sordidulum*, gen. et sp. nov.
Fourth peraeopod viewed obliquely from below.

The form of the abdomen in the male and female is shown in text-figs. 20*a* and 20*b*.

Except for the chelipedes of the male the entire upper surface of the animal is densely clothed with a fine woolly hair that retains large quantities of mud and can only be removed with considerable difficulty. Interspersed among the hairs are numerous large black bristles.

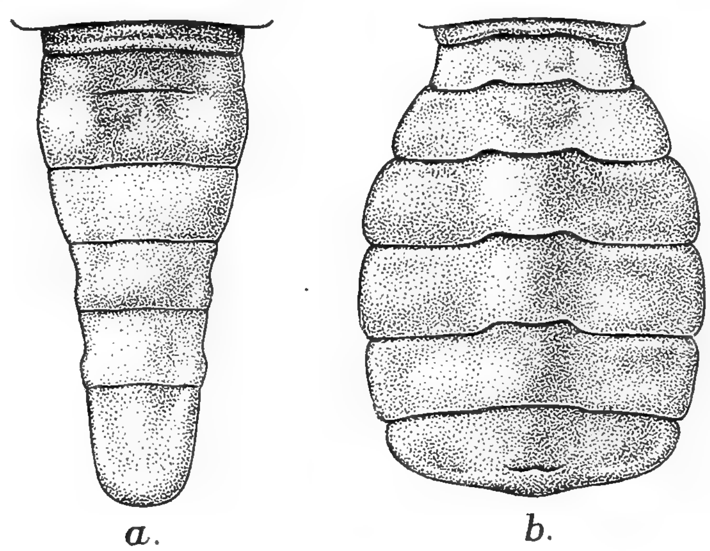


FIG. 20.—*Leipocten sordidulum*, gen. et sp. nov.
a. Abdomen of male. *b.* Abdomen of female.

The carapace of the largest female is 8·1 mm. in breadth, that of the largest male 6·5 mm.

Of this curious and variable species five females only were obtained in the Chilka Lake. All were found hiding among shells on the oyster-bed in the outer channel opposite Manikpatna. Two individuals were taken in March in water as salt as that of the Bay of Bengal in the vicinity of the lake (sp. gr. 1·0265), one in September in water that was quite fresh and two in December in water of specific gravity 1·0125. One of the specimens found on the last of these occasions is ovigerous.

A fine series of specimens, consisting of ten males and twenty-seven females, mostly ovigerous, was obtained by Dr. Annandale in the Ennur backwater near Madras in January 1915. They were found in cavities in laterite blocks forming a sea-wall, submerged at high water. The specific gravity of the water was 1·0025.

The types of the species bear the numbers 9163–4/10 in the Museum register.

Family PORTUNIDAE.

Genus **SCYLLA**, de Haan.

Scylla serrata (Forskål).

1899. *Scylla serrata*, Alcock, *Journ. Asiat. Soc. Bengal*, LXVIII, p. 27.

This species is common in the Chilka Lake, in the outer channel and in the main area, at all seasons of the year and is found both when the water is fresh and when it is as salt as the Bay of Bengal in the vicinity.

In young specimens, as Alcock has noted, the frontal lobes are indistinct and there is an interrupted transverse granular line across the gastric region; the latter is conspicuous even in specimens in which the carapace is 50 mm. in breadth.

Scylla serrata is the common edible crab of India and is brought into the markets in great numbers. It is abundant in estuaries, backwaters and mangrove swamps and is evidently able to live in water without a trace of salinity. In the Chilka Lake it must exist in fresh water for several months in the year and large specimens have been taken in the Gangetic delta far beyond the reach of tidal influence. The carapace of a male found under these conditions at Gatiaghar in the Hughli district is 135 mm. in breadth. The species, however, grows to a much greater size than this. In a giant male in the Indian Museum the carapace is 147 mm. in length and 211 mm. in breadth, the length of the larger chela being 195 mm. This individual is, I believe, the largest specimen known.

Examples of the Cirripede, *Dichelaspis cor*, Aurivillius, are commonly found attached to the branchiae of specimens found in the outer channel, but were never obtained on individuals caught in the main area of the lake.

Scylla serrata has a very wide Indo-pacific distribution extending from the Red Sea and the eastern coasts of Africa to Japan, New Zealand and Oceania. It is apparently not found at the Hawaiian Is.

Genus **NEPTUNUS**, de Haan.

1899. *Neptunus*, Alcock, *Journ. Asiat. Soc. Bengal*, LXVIII, p. 28.
1897. *Portunus*, Rathbun, *Proc. Biol. Soc. Washington*, II, p. 155.
1908. *Lupa*, Stebbing, *Ann. S. African Mus.*, VI, p. 11.[1]

Those interested in the question of the suppression of this long established name should consult the papers by Miss Rathbun and Stebbing cited above.

Neptunus pelagicus (Linnaeus).

1899. *Neptunus pelagicus*, Alcock, *Journ. Asiat. Soc. Bengal*, LXVIII, p 34.

This species is common in the Chilka Lake, both in the outer channel and in the main area; like *Scylla serrata* it is used as an article of food. It is, apparently, unaffected by alterations in salinity and is equally abundant at all seasons of the year.

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[1] In this paper Stebbing supports the claims of *Lupa* against those advanced by Miss Rathbun for *Portunus*. To these arguments Miss Rathbun has not, I believe, made any reply, yet continues to use *Portunus* for the species so long known by the unequivocal *Neptunus*, de Haan.

In very young specimens the carapace is proportionately much longer than in adults and the frontal margin is entire and not cut into teeth.

The range of the species in the Indo-pacific region is closely similar to that of *Scylla serrata*.

Genus **THALAMITA**, Latreille.

Thalamita crenata, Latreille.

1899. *Thalamita crenata*, Alcock, *Journ. Asiat. Soc. Bengal*, LXVIII, p. 76.

This species is not uncommon on the oyster-beds at Manikpatna in the outer channel of the Chilka Lake and was found both when the water was fresh and when it was salt. It does not, in our experience, occur in the main area of the lake.

The distribution of *T. crenata* is co-extensive with that of the two preceding species.

Tribe PAGURIDEA.

We are indebted to Dr. J. R. Henderson, Superintendent of the Madras Museum, for an account of the hermit-crabs of the Chilka Lake.[1]

The species identified by Dr. Henderson are seven in number. One of these is a form hitherto unknown, which is described under the name of *Clibanarius olivaceus*, and another, *Diogenes miles* (Herbst), is represented by a single individual obtained on the sea-shore near Rambha. The latter species is not a member of the lake fauna proper; it may perhaps wander at times to the shores of the outer channel, though we never found it there.

It is noteworthy that most of the Paguridea found in the lake are represented only by very small specimens. This is possibly due to the fact that their environment, with its great seasonal changes in salinity, hinders a more complete development; but it seems more probable that it is caused by the absence of any shells large enough to accommodate full-grown specimens. Except for a few *Telescopium fuscum*, found in the outer channel and frequently inhabited by moderate-sized *Clibanarius padavensis*, the largest gastropod both in this part of the lake and in the main area is *Thais* (=*Purpura*) *carinifera*, a shell much too small to accommodate large individuals of any species except *Diogenes avarus*. In the main area the distribution of *Thais* is restricted and coincides with that of *Clibanarius*.

Family PAGURIDAE.

Genus **CLIBANARIUS**, Dana.

The three species of this genus found in the Chilka Lake are very closely allied to one another; but, as Henderson has pointed out, are readily distinguished by their colouration. *C. padavensis* and *C. longitarsis* are very widely distributed forms, and all three are essentially inhabitants of brackish water.

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[1] Henderson, *Rec. Ind. Mus.*, XI, p. 25 (1915).

Clibanarius padavensis, de Man.

1915. *Clibanarius padavensis*, Henderson, *Rec. Ind. Mus.*, XI, p. 25.

This species, which has frequently been recorded from brackish water, is abundant at the south end of the lake, where it may be found crawling on the rocks at the base of Ganta Sila and on Breakfast I. It is also common in the outer channel, from Satpara at least as far as Manikpatna.

As is the case with all the Pagurids found in the lake, the species seems unable to exist on the soft mud of which the bottom is composed over the greater part of the main area. At the southern end it lives only on rocky or stony ground and in the outer channel on a foreshore of muddy sand or sand. The species appears to be wholly absent from Barkul Point and Patsahanipur. The shores in these localities seem as suitable as at the southern end of the lake, but gastropod shells of any size do not occur.

In the main area very young specimens are to be found in shells of *Potamides fluviatilis*, while the larger individuals inhabit *Thais carinifera*. In the outer channel adults make use of *Telescopium fuscum*, while young examples are found in *Potamides*, *Natica* and *Nassa labecula*.

C. padavensis is to be found in the lake at all seasons of the year and occurs in water that is fresh, brackish, or as salt as that of the open sea in the vicinity. Ovigerous females were obtained in March, both in the main area and in the outer channel, in water of specific gravity varying from 1·010 to 1·0265. Young specimens belonging to this genus are extremely scarce in the main area.

The species has a wide Indo-pacific distribution, extending from the western coasts of India to Australia and New Caledonia.

Clibanarius longitarsis (de Haan).

1887. *Clibanarius longitarsis*, de Man, *Arch. f. Naturgesch.*, LIII, i, p. 441.
1915. *Clibanarius longitarsis*, Henderson, *Rec. Ind. Mus.*, XI, p. 25.

Henderson notes that this species, which is not included in Alcock's Catalogue of the hermit-crabs in the Indian Museum, is the commonest brackish-water Pagurid on the Coromandel coast. It is apparently scarce in the Chilka Lake and is almost certainly absent from the Gangetic delta.

The two specimens in our collection were found in company with *C. olivaceus*, crawling on submerged stones at the sides of the landing stage on Barkuda I. They were obtained in September 1914, when the water was very slightly brackish (sp. gr. 1·0065) living in shells of *Thais carinifera*. The species probably occurs at the southern end of the lake throughout the year in water of specific gravity varying from 1·006 to 1·015.

The specimens are both very small; the length of the carapace in the larger is only 11 mm., whereas in an individual recently obtained by Dr. Annandale in the Ennur backwater near Madras it is fully 30 mm.

C. longitarsis is known to have a distribution extending from E. Africa to Japan.

Clibanarius olivaceus, Henderson.

1915. *Clibanarius olivaceus*, Henderson, *Rec. Ind. Mus.*, XI, p. 26.

This species, described by Dr. Henderson from material obtained in the Chilka Lake and readily distinguished from the two preceding forms by the absence of the conspicuous stripes on the second and third legs, is represented in our collection by seven specimens.

They were all obtained at the south end of the lake: on the rocks at the base of Ganta Sila in Febuary 1914, in water of specific gravity 1·010, and in September of the same year, in water of specific gravity 1·0065 on the landing stage at Barkuda I. At the former locality they were found in company with *C. padavensis*, at the latter with *C. longitarsis*, in both cases inhabiting shells of *Thais carinifera*.

Henderson also records specimens from the Adyar River and, in January 1915, Dr. Annandale obtained a single individual in the Ennur backwater, both localities being situated near Madras.

Genus DIOGENES, Dana.

Diogenes avarus, Heller.

1915. *Diogenes avarus*, Henderson, *Rec. Ind. Mus.*, XI, p. 28.

This species is very abundant in the outer channel of the Chilka Lake and in the salt-water season penetrates to Nalbano. It is not a permanent inhabitant of the main area.

Specimens were found in shells of *Potamides* and *Nassa* and were particularly abundant in the outer channel in September, living in water that was quite fresh: every time the Ω-net was hauled over the clean sandy ground opposite Manikpatna hundreds of examples were caught. Ovigerous females were found only in March, in water as salt as that of the Bay of Bengal in the vicinity of the lake-mouth. The hydroid *Clavactinia gallensis* was only found on shells occupied by this species.

Nobili[1] considers *D. avarus* a synonym of *D. pugilator* (Roux) and *D. varians* (Costa), the former name having priority. The species, as recognised by Alcock, has a distribution reaching from E. Africa to the Torres Straits and, if Nobili's synonymy be correct, has a much wider range, extending to the Mediterranean.

Family COENOBITIDAE.

Genus COENOBITA, Latreille.

With one exception all the specimens of this genus in our collection are very small and it is improbable that either of the species we obtained ever breeds in the lake. Examples of both forms were found in shells of *Natica*, a gastropod that does not occur in a living condition in any part of the lake-system. We regard the species as casual visitors rather than as permanent inhabitants.

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[1] Nobili, *Ann. Sci. nat.*, *Zool.* (9), IV, p. 119 (1906)

Coenobita rugosus, Milne-Edwards.

1915. *Coenobita rugosus*, Henderson, *Rec. Ind. Mus.*, XI, p. 29.

Two very young specimens were obtained in the outer channel between Manikpatna and the mouth of the lake. They were found crawling on the sandy shore of the outer bar in company with *C. cavipes*, and were living in shells of *Natica*.

At the time when they were obtained the water in the outer channel was fresh; but alterations in salinity must be of very little consequence to species of *Coenobita*, for they are typical land-hermits and live for the most part above water-level.

The geographical range of the species, according to Alcock, is Tropical West Africa: Red Sea littoral and East Africa, through the Indo-pacific to Vancouver, Lower California and Coquimbo.

Coenobita cavipes, Stimpson.

1915. *Coenobita cavipes*, Henderson, *Rec. Ind. Mus.*, XI, p. 29.

Small examples of this species were common at all seasons in the outer channel, both when the water was fresh and when it was salt. When the water is at its lowest, specimens may be found under the dry felted coating of algae which is exposed on the shores of the backwaters and among the islands. On the clean sand near the mouth of the lake the species is met with either walking in the open or sheltering in the burrows of *Ocypoda* and under drift wood.

A single large individual, with carapace 27 mm. in length, was obtained in December inhabiting a shell of *Ampullaria*. This gastropod is common in fresh water in the neighbourhood, but does not occur in the lake itself. The smaller specimens were living in shells of *Nassa*, *Potamides* and *Natica*.

Coenobita cavipes has a wide Indo-pacific distribution extending from E. Africa to the Loo Choo Is.

Tribe THALASSINIDEA.

Family CALLIANASSIDAE.

Subfamily *CALLIANASSINAE*.

Genus **CALLIANASSA**, Leach.

1903. *Callianassa*, Borradaile, *Ann. Mag. Nat. Hist.* (7), XII, p. 544.

The single member of this genus found in the Chilka Lake is identified with a form described by A. Milne-Edwards from a claw obtained in a sub-fossil condition in Siam. The species is closely allied to one found on the west coast of Africa, which appears triennially in the rivers in great numbers.

Callianassa (Callichirus) maxima, A. Milne-Edwards.

(Plate XIII, figs. 1-5.)

1870. *Callianassa maxima*, A. Milne-Edwards, *Nouv. Arch. Mus. Paris*, VI, p. 97.

The rostrum is sharply pointed, without lateral teeth, and is short, reaching barely to one-third the length of the eyes. There is no tooth on the frontal margin of the carapace between the eyes and the antennal peduncles (pl. xiii, fig. 1).

The eyes are subquadrilateral in dorsal view with their inner distal angles produced to a bluntly pointed process and their anterior margins oblique and concave. The inner margins are almost contiguous; they are straight and parallel with the outer margins. In the middle of the distal half there is a small round patch of black retinal pigment. The apices of the eyes reach a little beyond the articulation between the first and second antennular segments. The latter segment is stout, scarcely twice as long as broad. The third segment is more slender, but compared with some other species of the genus is comparatively short, less than one and a half times the length of the second. The distal extremity of the third segment reaches about to the middle of the terminal segment of the antennal peduncle. The antennal flagellum is apparently incomplete in the specimen described; it is, however, considerably longer than the subequal flagella of the antennules and is fully one and a half times the length of its peduncle.

The form of the outer maxillipede is shown in text-fig. 21*e*. The ischium, merus and propodus are extremely broad and on the inner face of the first of these segments there is a longitudinal row of small granules commencing close to the articulation with the basis.

The first legs are very unequal. In the larger—the right in the specimen described (pl. XIII, figs. 2, 3)—the ischium is slender, but considerably expanded towards its distal end. The inferior edge is finely but irregularly tuberculate, the tubercles sometimes taking the form of small spinules; on the outer surface in the proximal two-thirds there is a sharply defined crenulate carina. Between this carina and the lower margin, the surface is covered with close-set granules that extend nearly to the ischio-meral joint. The merus is a trifle longer than the ischium and is rather more than two and a third times as long as broad. In form it is trigonal, the outer surface being traversed longitudinally by a conspicuous ridge, smooth distally, but crenulate at its proximal end. The upper border is finely crenulate in its basal half; otherwise the surface above the median ridge is quite smooth. Below it the surface is covered with tubercles, which are larger towards the proximal end, and near the inferior margin there is an oblique granular crest. The inferior margin is granular and setose and near the ischial articulation is produced to a large acute tooth. On its inner face the merus bears two conspicuous grooves that run close to and parallel with, the upper and lower borders; the surface is granular at the proximal end, otherwise quite smooth.

The carpus of the same limb is one-third broader than long; its length is about two-thirds that of the merus. The outer surface is smooth and evenly convex. The posterior margin below the mero-carpal joint is setose and a little uneven and the infero-distal angle bears a few spinules at its apex. On the inner surface the upper limit of the excavation into which the merus fits is defined by a strongly granular ridge and there are also scattered tubercles near the sharp crest that forms the upper margin and near the inferior angle. The distal margin, next the propodus, is finely crenulate internally; externally it is smooth.

The palm of the chela, measured along its upper margin, is one quarter longer than the carpus and is equal in breadth with that segment; it is rather more than

two-thirds the length of the dactylus. The upper margin of the palm, in its basal two-thirds only, bears a sharp ridge that is obscurely notched. The outer surface of the palm is evenly convex and the whole of its middle part is covered with granules which increase in size distally. Close to the gape of the fingers there is a cluster of large spinules and at the proximal end of a smooth blunt ridge that extends the entire length of the fixed finger there is a short row of rounded tubercles. On the inferior edge of the palm there is a series of close-set spinules. The inner face of the palm is covered with granules larger than those on the external surface and there are a few tubercles near the gape of the fingers. The inner edge of the fixed finger is without teeth and is feebly crenulate at the proximal end. In the gape at the base of the dactylar articulation is a blunt lobe serrated at the distal end. When the claw is closed the fingers meet only at the tip. The dactylus is curved and pointed at the apex and bears a few coarse and rather obscure tubercles on its upper margin near the base. On the inner edge there is a large bluntly trilobed tooth at the proximal end, a single large blunt tooth in the middle of the margin and a series of seven smaller teeth, also blunt, behind the tip. On both upper and lower margins of the palm and on the fingers are numerous tufts of coarse yellowish setae.

The smaller left leg of the first pair (text-fig. 21*f*) is totally different in form and bears no spinules or tubercles. The merus is about twice as long as broad and is longer than the ischium; the outer surface shows traces of a ridge. The carpus is about two and a half times as long as wide; the upper and lower margins are sharply crested and, throughout the greater part of their length, are strictly parallel. The chela is a little shorter than the carpus and about one and a half times the length of the merus. The fingers are about as long as the palm; they are obscurely serrate internally and bear tufts of coarse setae.

The form of the remaining pairs of legs is illustrated in text-figs. 21*a-d*. The propodus in the third pair bears a conspicuous lobe on its inferior margin; the fifth pair is perfectly chelate.

The second abdominal segment is the longest, equal to the fourth and fifth combined and a little longer than the sixth. There is a patch of soft hairs on the postero-lateral angles of the third and fourth and a similar patch in the middle of the fifth. The sixth somite is subcircular, narrower than the fifth; it is excavate on either side in the posterior third and in the middle of the distal margin there is a short longitudinal furrow (pl. xiii, fig. 5). The first two abdominal appendages are slender; the remaining three are broadly foliaceous.

The telson (pl. xiii, fig. 5) is subquadrilateral, little more than half the width of the sixth somite and one quarter broader than long. The lateral margins are gently rounded and the posterior margin slightly convex with a tuft of long setae on either side. In the middle of the upper surface there is a smooth hemispherical swelling, bearing tufts of setae, and behind this swelling are three conspicuous dimples, the middle one larger than the two lateral.

The uropods are much longer than the telson. The inner is triangular in shape,

the outer ovoid, with a small bilobed tubercle against which the endopod is folded when the tail-fan is closed.

The above description is taken from an individual, nearly 80 mm. in total length, that was obtained by purchase many years ago at Madras. The propodus of the larger first leg in this specimen is 23 mm. in length.

The material obtained in the Chilka Lake consists only of a solitary large leg belonging to the first pair and of two small and immature individuals.

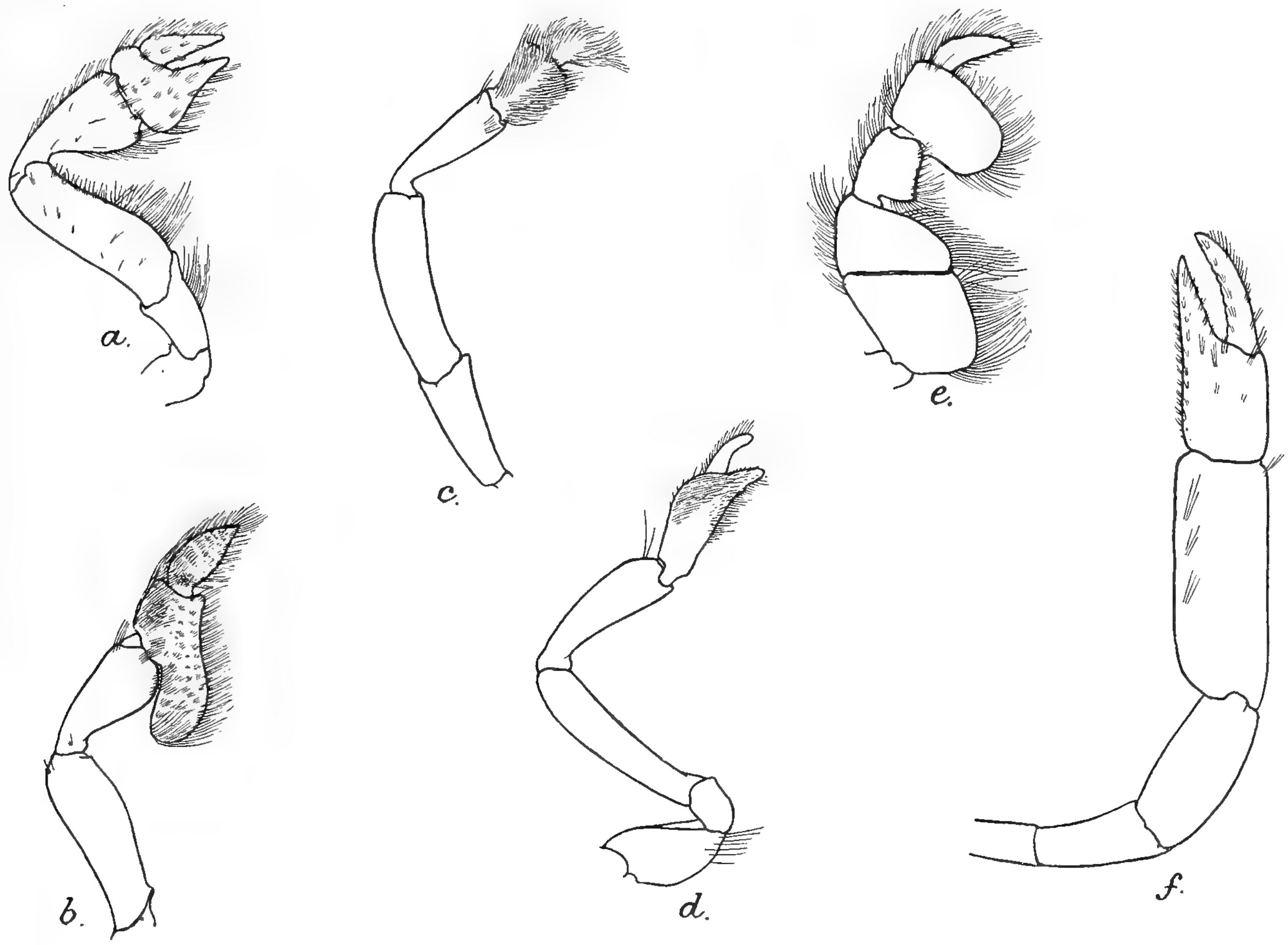

FIG. 21.—*Callianassa (Callichirus) maxima*, A. M.-Edw.

a. Second peraeopod.
b. Third peraeopod.
c. Fourth peraeopod.
d. Fifth peraeopod.
e. Third maxillipede.
f. Smaller peraeopod of first pair.

The large leg bears a close resemblance to that of the complete individual from Madras (pl. xiii, fig. 4) but the lower border of the merus is armed with large irregular spinules (the proximal one of the series taking the form of a bilobed tubercle); the tubercles on the upper edge of the dactylus, near the base, are more prominent and the surface granulation is in most places more scanty. The last feature is doubtless correlated with age; the chela found in the Chilka Lake evidently belonged to a smaller specimen than that from Madras, the propodus being only 17 mm in length. The teeth on the inner edge of the dactylus are closely similar to those of the Madras specimen, but the series near the tip consists only of four teeth.

The largest of the two immature individuals is only 15 mm. in total length. The eyestalks have the same form as in the adults, but are rather more convex dorsally and the patch of retinal pigment is proportionately much larger. The segments of the antennal and antennular peduncles are of proportions similar to those of adults and this is also true of the first legs, except that, in the larger of the two, the carpus is rather longer in comparison with its breadth. None the less there is still a very great difference in this respect between the right and left carpus of this pair. The fingers of the large chela, which is little more than 3 mm. in length, show only faint indications of teeth and the surface of the entire limb is smooth and polished. The telson is similar to that of the adult, but the sculpture is less defined.

Callianassa maxima was described by A. Milne-Edwards from a single chela of gigantic dimensions obtained in a sub-fossil condition in Siam, many miles from the sea. This chela is 60 mm. in length, nearly three times the size of that of the individual from Madras. The granulation as described and figured in the sub-fosssil chela is much more pronounced than in any of the living examples obtained on the Indian coast; but this, I believe, is largely a matter of age. The armature of the inner margin of the dactylus is apparently very characteristic and in this respect there is the closest possible resemblance between the Indian specimens and that from Siam.

That this species, hitherto known only as a fossil, should now be discovered in a living state need occasion no great surprise; A. Milne-Edwards at the end of his description remarks[1] "Peut-être dècouvrira-t-on un jour que cette espèce vit encore sur les côtes de Siam, car il est probable que les alluvions dans lesquelles elle a été trouvée sont relativement peu anciennes et analogues à celles qui existent sur certains rivages des mers de Chine et de l'océan Indien, ou on a rencontré à l'état fossile des espèces de crustacés qui aujourd'hui vivent encore dans les mêmes mers, tels que la *Scylla serrata* et l'*Ixa canaliculata*, à côté d'espèces inconnues aujourd'hui, telles que le *Macrophthalmus Latreillei.*" Since this passage was written living examples of the last named species have been found.

Callianassa maxima is apparently allied to *C. turnerana*, White[2], but the latter species is readily distinguished by the armature of the merus and dactylus of the larger chelipede, by the absence of surface granulation on this limb, by the much shorter carpus of the smaller chelipede, by the trispinous rostrum and by the form of the telson. *C. turnerana*, with which *C. diademata*, Ortmann, is apparently synonymous[3], is found in the Cameroons in W. Africa, in the rivers of which it is sometimes found in prodigious numbers. According to Vanhöffen[4], the species is restricted to brackish water and the swarms appear at intervals of approximately three years, a period which he regards as that of the normal life-cycle.

The history of the Madras specimen is unknown; it probably came from one of the backwaters in the vicinity of that city. Of the Chilka specimens, the solitary large limb (which contains muscular tissue and is not merely a dessicated fragment) was

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[1] *loc. cit.*, p. 98.
[2] White, *Proc. Zool. Soc., London*, 1861, p. 42, pl. vi.
[3] Lenz, *Sitz-ber. Ges. naturf. Freunde, Berlin*, 1911, p. 316.
[4] Vanhöffen, *ibid.*, 1911, p. 105.

obtained in March on the shores of Nalbano I. in water of specific gravity 1·008. The two immature individuals were found in September in water that was almost or quite fresh. Both were taken in soft muddy sand; one at Nalbano I. and one near Barhampur I. in the outer channel. The species apparently lives only in mud mixed with a considerable proportion of sand. It is doubtless a permanent inhabitant of the lake, able to exist in water of specific gravity varying from 1·000 to 1·0265.

The precise locality of the subfossil Siamese specimen is not stated. It was found while cutting a canal at a great distance from the sea.

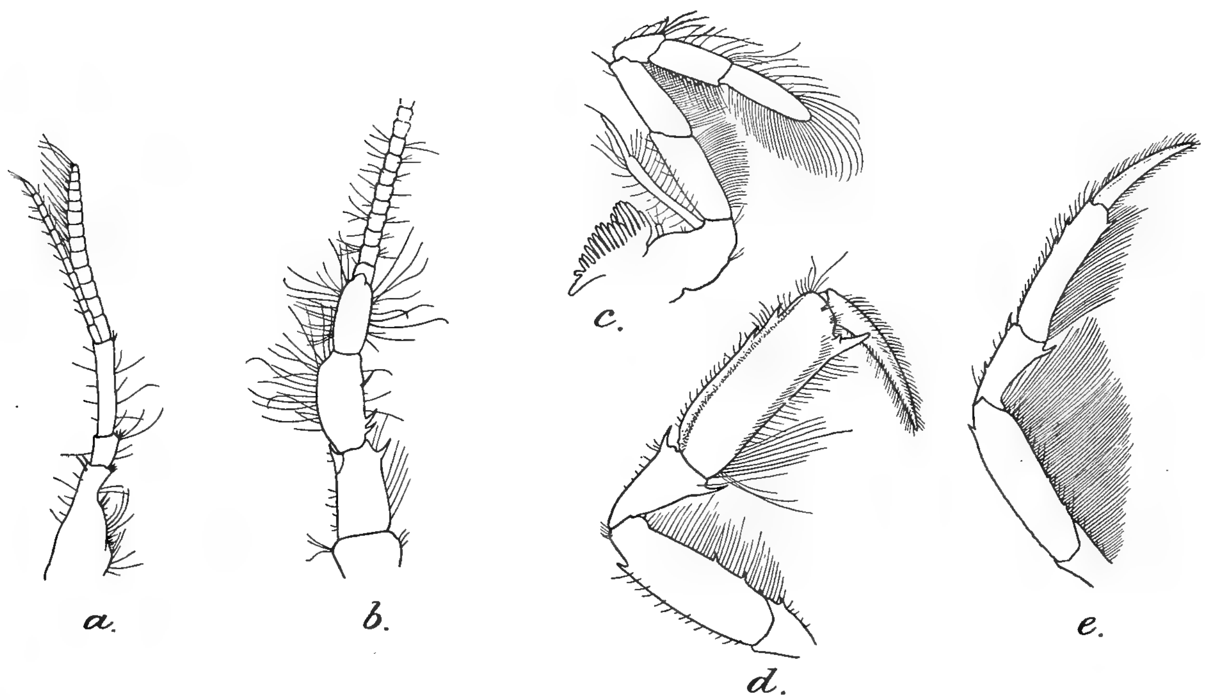

FIG. 22.—*Upogebia* (*Upogebia*) *heterocheir*, sp. nov.

a. Antennule, dorsal view.
b. Antennal peduncle, lateral view.
c. Third maxillipede.
d. First peraeopod of male.
e. First peraeopod of female.

Subfamily *UPOGEBIINAE.*

Genus **UPOGEBIA**, Leach.

1903. *Upogebia*, Borradaile, *Ann. Mag. Nat. Hist.* (7), XII, p. 542.

The single species of this genus found in the Chilka Lake is remarkable for the differences that exist between the sexes in the form of the first pair of legs. In the male these limbs are sub-chelate, whereas in the female they are monodactylous.

Upogebia (Upogebia) heterocheir, sp. nov.

(Plate XIII, figs. 6, 7.)

The rostrum is slightly inclined downwards and reaches beyond the end of the eyes by nearly half its length. In dorsal view it is narrow with a rather sharply rounded apex which is not provided with teeth or spinules (pl. xiii, fig. 6). The

lateral tooth on each side is long and sharp and, when seen from above, is separated from the margin of the rostrum proper by a V-shaped incision which is continued backwards in the form of a deep furrow almost to the cervical groove. External to this furrow and parallel with it is a strong ridge which extends to the tip of the lateral tooth. These ridges and the upper surface of the rostrum are covered with fine hair, but are otherwise smooth and without trace of granules or tubercles.

The carapace behind the deeply cut cervical groove is smooth and polished. On the frontal margin behind the eye there is a small and inconspicuous tubercle, sometimes almost obsolete, and where the cervical groove is cut by the linea thalassinica there is a stout hepatic spine.

The antennular peduncle extends but little beyond the rostrum. The third segment is very slender and fully three times the length of the second (text-fig. 22*a*); the flagella are subequal, about three-quarter the length of the peduncle. The antennal peduncle is composed of only four distinct segments (text-fig. 22*b*). At the distal end of the second segment there is a large ventral spine and, not infrequently, a small dorsal spinule. Superiorly, between the second and third segments, is a small articulated piece consisting of a single tooth with a broad base; this is apparently a rudiment of the antennal scale and not a vestige of the suppressed segment. The third segment bears one, less commonly two teeth on its ventral margin near the proximal end.

On the third maxillipedes (text-fig. 22*c*) there is a rudimentary epipod.

The first legs are subchelate in the male (text-fig. 22*d*), monodactylous in the female (text-fig. 22*e*). In both sexes they reach beyond the rostrum by the whole of the last three segments. There is a spinule on the lower margin of the ischium and a series of from 2 to 6 on the same edge of the merus. The upper border of the latter segment is unarmed except for one (rarely two) subterminal spines. The carpus is much widened distally and is little more than half the length of the merus. It bears three or four spines. Three of these are placed at the distal end, one above, one below and one on the inner side; the fourth, which is rarely absent[1], is smaller than the others and is situated on the upper margin at about the middle of its length. The propodus is longer than the merus and, on its upper edge, bears from two to four spines. In adult males it is from two and a half to three times as long as broad, whereas in females, in which the whole limb is more slender, it is fully four times as long as broad. In the latter sex there is only a comparatively small subterminal spine on the under margin; in the male it is much enlarged forming, with the dactylus, a subchela. This tooth or fixed finger of the male is less than half the

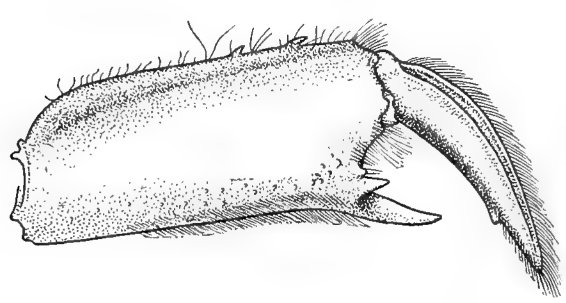

FIG. 23.—*Upogebia* (*Upogebia*) *heterocheir*, sp. nov.

Last two segments of the first peraeopod of a large male; from a cast skin.

[1] It is absent in text-fig. 22*d*.

length of the dactylus; the margin opposed to the dactylus is entire, but externally near the base it bears a large blunt spine or tubercle. Externally the propodus is longitudinally grooved near the upper border, while near the lower border is a row of setae. The inner surface is smooth, but near the upper border is traversed longitudinally by a row of pits from which setae arise. The dactylus is ridged dorsally throughout its length; there are no teeth or serrations on the lower edge. In the chela of a very large male, represented merely by a cast skin (text-fig. 23), there are a few scattered tubercles on the outer surface of the palm near its inferior edge; the dactylus bears two strong ridges on its upper surface and a blunt tooth in the distal half of its lower margin.

There are no spines on the basal segments of the last four legs. In the second pair (text-fig. 24*a*) the merus bears two or three spines, one, which is subterminal, on

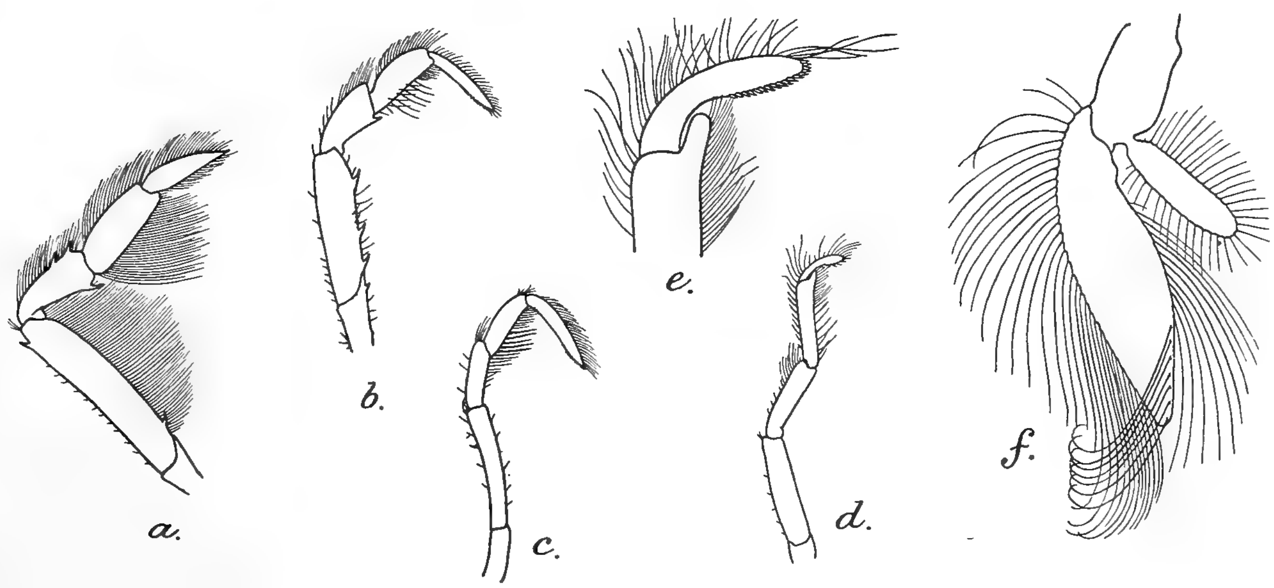

FIG. 24. –*Upogebia* (*Upogebia*) *heterocheir*, sp. nov.

a. Second peraeopod of male.
b. Third peraeopod of male.
c. Fourth peraeopod of male.
d. Fifth peraeopod of male.
e. Terminal joint of same, further enlarged.
f. Second pleopod of male.

its upper edge and one or two below, one proximal and one near the middle, the latter sometimes absent. The carpus bears three spines; two placed close together in the distal half of its upper border and one situated beneath them, on the lower border. In the third legs (text-fig. 24*b*) there are from 3 to 6 spines on the lower margin of the merus and one in the same position on the carpus. In the fifth the propodus projects a little beyond the articulation of the dactylus; but the limb could scarcely be termed subchelate (text-figs. 24*d*, *e*).

The branchial formula consists of ten arthrobranchs on each side, arranged in pairs at the base of the third maxillipedes and first four legs. There are no branchiae above the fifth legs.

Except for fine scattered setae, most conspicuous on the lateral margins, the abdominal somites are smooth and polished. The sixth somite (pl. xiii, fig. 7) is the longest, almost one and a half times the length of the second. In dorsal view the

sides of the fifth somite are strongly convex, while those of the sixth are concave in the anterior three-quarters of their length. The sixth segment is widest posteriorly.

The telson is a little broader than long (pl. xiii, fig. 7); its lateral margins are somewhat convergent and the apex is noticeably emarginate. On the upper surface there is an obscure $\cap$-shaped ridge, the extremities of the $\cap$ being directed towards the postero-lateral angles. In the middle line there is an obscure sulcus and on either side, external to the $\cap$-shaped ridge, there is a well-marked longitudinal groove. On the dorsal surface of both inner and outer uropods there are two blunt ridges.

A large male is only 23 mm. in length.

Upogebia heterocheir appears to differ from all known species of the genus in the remarkable sexual differences in the first pair of legs and, apart from this feature, is distinguished by the position of the spines on the leg-segments and other characters. in the Chilka Lake it is probably abundant; but, owing to its burrowing habits, it was difficult to obtain any number of specimens. It is, however, represented in our collection by thirty-two individuals, mostly small, and a number of cast skins.

The species is a permanent inhabitant of the lake; it was found both in the main area and in the outer channel at all seasons of the year, in water of specific gravity varying from 1·000 to 1·0265. It seems to prefer a bottom composed of mud with a considerable admixture of sand and it was on ground of this character near Nalbano and off Barhampur I. that the majority of our specimens were obtained. In several localities cast skins were taken in abundance and it is evident that the act of exuviation is performed simultaneously by a large number of individuals. Cast skins were found in February and in September; it is probable, therefore, that there are at least two moulting periods in the course of the year.

Ovigerous females were found only in the months of November and December, in water of specific gravity varying from 1·001 to 1·0125. The eggs are large, about 0·74 mm. in longer diameter.

The type specimens are registered under no. 9304/10.

DECAPODA NATANTIA.

Tribe CARIDEA.

Family CRANGONIDAE.

Genus PONTOPHILUS, Leach.

1912. *Pontophilus*, Kemp, *Rec. Ind. Mus.*, VI, p. 8.

In the paper quoted above I have endeavoured to show that the genera *Pontophilus*, Leach, and *Philocheras*, Stebbing, must be united, the former name having priority. Though such extreme forms as *spinosus* (Leach) and *echinulatus* (M. Sars) are readily distinguished by several features which at first sight seem of generic value, there exist species almost precisely intermediate in character. Any division into two genera must, I believe, be of an arbitrary nature and can only tend to obscure the affinities of the species comprised in the series.

In the species here described the lateral process of the antennular peduncle is distally rounded, there is no exopod on the first peraeopods, the second peraeopods are comparatively long and reach to the carpus of those of the first pair and there is no appendix interna on the pleopods. In these particulars the species agrees with *echinulatus* (M. Sars) and with *bispinosus* (Westwood, = *nanus*, Kröyer), the latter of which may be taken as the type of Stebbing' s *Philocheras*.[1]

Pontophilus hendersoni, sp. nov.

(Plate XIII, fig. 8.)

In general appearance this species bears a close resemblance to *P. bispinosus* (Westwood).

The rostrum is broad, parallel-sided, and bluntly rounded apically; it is deeply channelled longitudinally, the margin forming a raised rim which is contained laterally round the orbits.

In dorsal view, the carapace including the rostrum) is a little longer than broad. Situated in the mid-dorsal line near the rostral base there is small, sharp, forwardly directed spine, which does not, as in many other species, form the termination of a median carina. On either side behind the middle of the orbit, there is in the anterior third of the carapace a blunt longitudinal ridge, which posteriorly sinks imperceptibly to the general level of the carapace, but anteriorly terminates abruptly in the same latitude as the median spine. A feeble groove defines the upper limit of the branchial chamber and is continued forwards as a shallow depression towards the base of the antennae. This depression is bounded beneath by a blunt ridge which is co-terminous anteriorly with the acute antennal spine. There is no hepatic spine. The branchiostegal spine is large and sharp; it is flanked by a short carina and extends far beyond the level of the rostrum (pl. xiii, fig. 8).

The thoracic sterna are broad posteriorly. The last four are furnished with blunt carinae in the middle, each of which terminates anteriorly in a short spine. In front of them a long and sharp spine projects forwards between the bases of the first legs.

The eyes are deeply pigmented; their shape, including the stalks, is almost globular. The basal segment of the antennular peduncle does not bear spines either ventrally or at its outer distal end; its lateral process is subquadrate in outline and is not pointed anteriorly; the second segment is considerably longer than the third; the greatly swollen outer flagellum of the male is about one and a half times the length of the peduncle (text-fig. 25*b*). The antennal scale is about two and a quarter times as long as broad (text-fig. 25*a*). The outer margin is almost straight and terminates in a large spine which reaches as far forwards as the rather sharply angled apex of the lamella.

The ultimate segment of the outer maxillipede is broadly rounded apically and scarcely reaches beyond the distal end of the scale.

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[1] Stebbing, *Marine Invest. S. Africa*, I, p. 48 (1902).

The first legs (text-fig. 25*c*) reach almost as far forwards as the outer maxillipedes and do not possess exopods. The merus bears externally a small procurved tooth a little behind its distal end. The carpus is short and apparently does not bear spines. The hand is very broad; the "thumb" of the subchela is extremely large and the maximum breadth, "thumb" included, is considerably more than half the total length. A peculiar feature of the thumb-tooth is that its apex is bifid, composed of two closely adjacent spines (text-fig. 25*c'*). There are coarse serrated hairs at the inner angle of the carpus and on the adjacent margin of the propodus. Finer hairs occur on the cutting edge of the latter segment and on the margins of the merus.

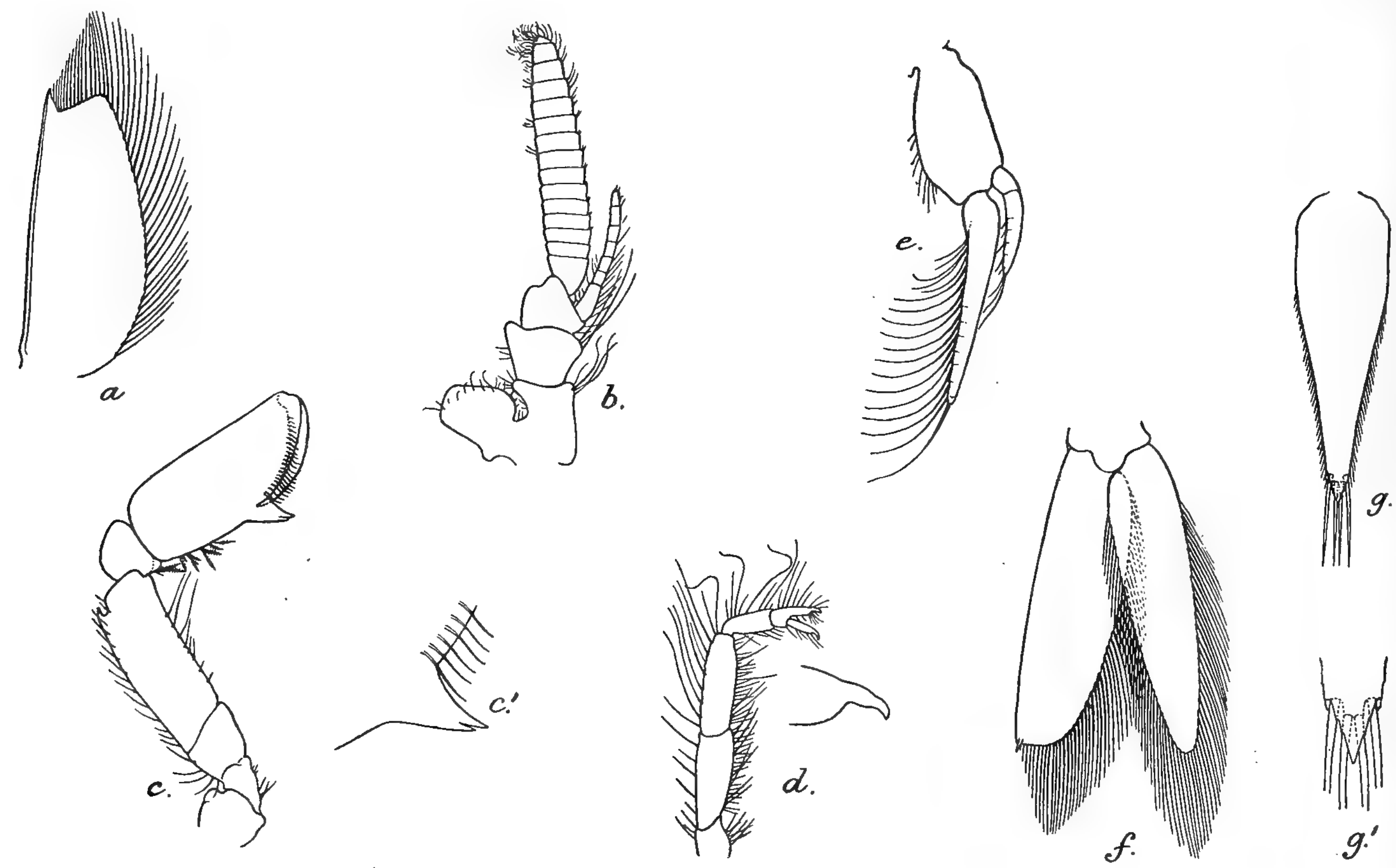

FIG. 25.—*Pontophilus hendersoni*, sp. nov.

a. Antennal scale.
b. Antennule of male.
c. First peraeopod. *c'.* The 'thumb' of the sub-chela further enlarged.
d. Second peraeopod, with apex of fixed finger further enlarged.
e. Second pleopod of male.
f. Outer and inner uropods.
g. Telson. *g'.* Apex further enlarged.

The second legs (text-fig. 25*d*) reach about to the end of the carpus of the first pair and are clothed with fine hairs. The merus and ischium are broad and about equal in length; the carpus is little more than half as long, but is as long as and stouter than the chela. The latter is weakly constructed; the fingers are nearly twice the length of the palm and the inner edges meet throughout their length when the claw is closed; each finger is noticeably constricted at the apex and does not bear a distinct claw.

The third legs are very slender and reach to the apex of the antennal scale. The merus is one and a third times the length of the ischium and is a little shorter than

the carpus. The propodus and dactylus are partially fused; taken together, their length is slightly shorter than that of the merus. Close to the apex of the dactylus there is a small tuft of setae.

The fourth and fifth legs are similar, stouter than those of the third pair. In the fourth pair, which reaches a little beyond the apex of the antennal scale, the merus is the longest segment, almost twice the length of the dactylus. The carpus is a little more than two thirds the length of the merus and is a little shorter than the propodus and a little longer than the ischium. Except for a few hairs on the latter segment and at the base of the merus the segments are naked.

There are no longitudinal carinae on any of the abdominal somites and, except for a feeble transverse groove near their posterior margins, the first five abdominal somites are unsculptured; on the dorsal surface of the third somite, however, not far from the distal margin, is a small tubercle which is a very conspicuous feature in lateral view. The sixth somite is about one and a half times the length of the fifth and is only a trifle shorter than the telson.

The inner branch of the pleopods is in all cases very short and does not bear an appendix interna. Judging from differences in the proportions of the outer antennular flagellum the majority of the specimens obtained are males; in no individual, however, have I been able to find a trace of the appendix masculina (text-fig. 25*e*).

The uropods (text-fig. 25*f*) are a little longer than the telson: the exopod is about three and a half times as long as wide. The telson (text-fig. 25*g*) is not sulcate above and is much narrowed distally: it has setose margins but no dorsolateral spinules. The apex (*g′*) is very narrow and is formed by an acutely triangular plate bearing two pairs of fine plumose setae.[1] On either side at the base of this plate is a short and blunt spinule and between these spinules (underneath the plate) are two pairs of very large setae.

The largest specimen is only about 10 mm. in length; but is, I believe, fully adult.

The colouration of the species in life is very variable. As a rule there are two transverse bars of dark reddish-brown pigment, one in the anterior half of the carapace and another on the fourth abdominal somite. There are also on the dorsal surface several large black or dark brown chromatophores, the distribution of which is very irregular, and frequently a large white spot at the proximal end of the last abdominal somite. The margins of the abdominal pleura are umber brown; the upper edge of the first legs and the basal segments of the first four legs and last two swimmerets are dark.

Pontophilus hendersoni bears little resemblance to any other Indo-pacific species of the genus. Its nearest ally appears to be *Pontophilus bispinosus* (Westwood), a common European species; from this form, however, it is easily distinguished by the sculpture of the carapace and by numerous minor details.

The species is described from thirteen specimens found in March 1914, in the outer channel of the Chilka Lake. They were caught in nets hauled at a depth of

[1] Not shown in text-fig. 25*g′*.

1 or 2 feet over the hard sand near the mouth of the lake. At the time when they were obtained the water in the outer channel was as salt as that of the sea outside the lake. In September 1914, when it was quite fresh we searched carefully for the species in the same place, but were unable to discover any more specimens. The species appears to be only a casual visitor to the extreme outer parts of the lake during the salt-water season.

The type specimens bear the no. 8970/10 in the Museum register.

Family PALAEMONIDAE.

Borradaile in a short preliminary paper, recently published [1], has divided the Palaemonidae into four sub-families, the Desmocaridinae, Pontoniinae, Palaemoninae and Typhlocaridinae. The characters used in the separation of the first three of these subfamilies are, in the main, those to which Sollaud has already drawn attention. I am inclined to think that the arrangement suggested is not likely to be permanent; but the number of forms obtained in the Chilka Lake is so small that the occasion is not a suitable one for a discussion of the matter.

The Palaemonidae found in the lake comprise seven species belonging to the genera *Palaemon*, *Leander*, *Urocaris* and *Periclimenes*. The last two genera are represented by single species which are described as new; they are able to live in either fresh or salt water and to tolerate considerable periodic variations in salinity. Both species occur among weeds and *Urocaris* is one of the commonest and most widely distributed Crustacea in all parts of the lake: the *Periclimenes* is found only in the outer channel.

The single species of *Leander* and one of the Palaemons, *P. scabriculus*, must be regarded as casual visitors to the lake, the former from the sea, the latter from the ponds or rice fields.

Only females of *Palaemon malcolmsoni* and *P. lamarrei* have been found in the lake and our observations lead us to conclude that these species visit its waters only for breeding purposes. This is also the case with the remaining species of the genus, *P. rudis*, the males of which accompany the females at this period. Adults of these three forms do not live in water as salt as that of the Bay of Bengal; but the young of *P. rudis* were found in the outer channel at the salt-water season, while adults of *P. lamarrei* are able to tolerate a considerable degree of salinity. *P. malcolmsoni* was found only in fresh water.

Although the species of *Periclimenes* and *Urocaris* are here described as new, they also occur at other places on the east coast of India, the *Periclimenes* at the mouth of the Adyar river at Madras, the *Urocaris* in backwaters in the same neighbourhood and also in pure sea-water inside the coral reefs and in the shallows of the Gulf of Manaar. The *Urocaris* is a very close ally of a species found in the Gulf of California and on the Pacific Coast of Mexico.

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[1] Borradaile, *Ann. Mag. Nat. Hist.* (8), XV, p. 206 (1915).

Genus PALAEMON, Fabricius.

Palaemon lamarrei, Milne-Edwards.

1908. *Palaemon (Eupalaemon) lamarrei*, de Man, *Rec. Ind. Mus.*, II, p. 222, pl. xix, fig. 4.

This species is represented in our collection by numerous specimens found at Rambha in February and at Barkul in March 1914. All the larger examples are females and a great number bear eggs.

The measurements (in mm.) of four specimens are as follows[1]:—

Sex.	Total length.	Length of carapace.	Length of chelipede.	Chelipede (2nd leg): length of				
				Ischium.	Merus.	Carpus.	Palm.	Dactylus.
♀	58	13·4	25·5	5·0	5·7	8·0	3·4	2·6
♀	54	12·4	22·6	4·5	5·1	7·1	2·6	2·1
♀	50	11·0	21 6	4·4	5·0	6·9	2·3	2·0
♀	44	9·6	19·0	4·1	4·3	6·0	1·9	1·7

It will be noticed that there is some difference between these figures and those given by de Man for younger specimens; the carpus, in particular, though still decidedly longer than the chela, is proportionately shorter.

The rostrum, in adult females, reaches only to the apex of the antennal scale, or a little beyond it. In other respects the specimens agree closely with de Man's description.

Henderson and Matthai have pointed out[2] that the eggs in this species are very large and by hatching experiments have succeeded in proving that development is direct and without metamorphosis. In the Chilka specimens eyed eggs average 1·5 mm. in length by 1·1 mm. in breadth, measurements which differ somewhat from those obtained by the above-mentioned authors from specimens found near Madras.

Palaemon lamarrei, originally described by Milne-Edwards from the coasts of Bengal, is common in the Gangetic Delta in fresh or slightly brackish water and, as noticed above, has been found near Madras. De Man (*loc. cit.*) has pointed out that

[1] In this table, and in the measurements given on succeeding pages, the total length is taken from the tip of the rostrum to the apex of the telson and the length of the carapace from the back of the orbit to the mid-dorsal point at its posterior end. The chelipede is measured from the basipodite (which forms a convenient point of application for a pair of callipers) to the tip of the chela. In the case of individual segments the measurements represent the greatest length of each segment. The instrument used in taking all measurements under 100 mm. is a pair of callipers fitted with a dial which gives direct readings to ·1 mm.

[2] Henderson and Matthai, *Rec. Ind. Mus.*, V, p. 301 (1910).

the records by Ortmann from Brazil and by de Haan from Japan are to be discredited.

In the Chilka Lake the species is not abundant, but was found in some numbers in February 1914, near Rambha, when the specific gravity of the water was 1·011. The specimens, however, were taken near the mouth of a small stream and in this locality the water was doubtless less salt than in other places in the vicinity. The examples obtained in March of the same year at Barkul were caught by fishermen.

The large number of ovigerous females in the collection, and the total absence of individuals which can be recognised as males, are facts which suggest that the species migrates from the fresh water in the neighbourhood to liberate its young in the lake.

Palaemon malcolmsoni, Milne-Edwards.

1910. *Palaemon malcolmsoni*, Henderson and Matthai, *Rec. Ind. Mus.*, V, p. 83, pl. xv, figs. 2*a–f*.

Ten large ovigerous females of this species were obtained in September 1914, at Barkul, in company with numerous examples of *Palaemon rudis*.

The rostrum, in its shape and dentition, agrees precisely with the description given by Henderson and Matthai. The measurements of the specimens (in mm.) are as follows:—

Number.	Total length.	Length of carapace.	Length of right chelipede.	Length of left chelipede.	Larger chelipede: length of					Proportionate length of segments of larger chelipede to total length of chelipede (100):				
					Ischium.	Merus.	Carpus.	Palm.	Dactylus.	Ischium.	Merus.	Carpus.	Palm.	Dactylus.
1	136	37·9	108	108	19·9	21·4	27·5	20·3	16·9	18·2	19·6	25·2	18·6	15·5
2	136	36·5	101	104	18·8	20·4	25·9	20·0	16·7	18·0	19·6	24·9	19·2	16·0
3	125	30·5	97	98	17·1	18·4	22·2	19·7	16·5	17·4	18·8	22·6	20·1	16·8
4	122	35·3	98	93	17·5	19·5	22·8	20·5	14·9	17·8	19·9	23·3	20·9	15·2
5[1]	122	29·9	88	92	15·9	18·7	20·5	20·6	14·1	17·3	20·4	22·3	22·5	15·4
6	119	32·4	81	86	15·8	16·1	19·6	16·6	13·2	18·3	18·7	22·7	19·3	15·3
7	116	31·7	84	84	15·3	16·8	20·4	15·4	12·2	18·2	20·0	24·3	18·3	14·5
8	116	29·4	77	78	14·4	15·2	18·8	15·2	11·1	18·4	19·5	24·1	19·5	14·2
9	105	27·5	73	78	14·0	14·6	17·8	16·0	11·9	17·9	18·7	22·8	20·5	15·2
10	107	28·8	72	77	13·0	15·2	18·3	15·1	10·2	16·9	19·8	23·8	19·6	13·6
								Average	..	17·8	19·5	23·6	19·7	15·2

At the time of their capture the distinctions between these specimens and females of *Palaemon rudis* were not appreciated. The two forms may be distinguished by the following characters:—

[1] The palm in this specimen is quite abnormal in length and has been omitted in calculating the average proportionate length of the segment. The palm of the other chelipede in the same individual is of normal dimensions.

P. malcolmsoni, ♀.	*P. rudis*, ♀.
Rostrum longer, reaching to or beyond apex of antennal scale; proximal margin of upper border markedly convex, apex a little upturned. Dorsal teeth aggregated on proximal part; teeth on distal part few, either confined to apex or very widely separated. Three dorsal teeth on carapace.	Rostrum shorter, reaching at most to apex of antennal scale. Upper margin straight or very slightly convex, apex not upturned. Dorsal teeth almost evenly spaced throughout length of rostrum. Two dorsal teeth on carapace.
Inner and outer margins of antennal scale subparallel.	Inner and outer margins of antennal scale anteriorly convergent.
Chela of first peraeopods with fingers decidedly shorter than palm. Palm with large patch of coarse setae on its infero-internal aspect. Fingers gape at base when claw is closed.	Chela of first peraeopods with fingers equal in length to palm. Palm with small patch of coarse setae on its infero-internal aspect. Fingers do not gape at base when claw is closed.
Second peraeopods with fine spinules arranged in longitudinal rows. Dactylus in very old females densely covered with hairs. Carpus shorter than palm + half the length of fingers.	Second peraeopods practically glabrous. Carpus longer than palm + half the length of fingers.

A series of very much smaller specimens found at Satpara in March 1914 may also belong to this species, though they differ markedly from the larger individuals noticed above. The series comprise several ovigerous females and a few males in which the appendix masculina is to all appearances fully formed; the largest specimen, an egg-bearing female, is 58·5 mm. in total length. The great difference in size between this individual and those found at Barkul is not, of itself, sufficient to disprove the specific identity of the two series of specimens. Henderson and Matthai have pointed out that species of *Palaemon* may be sexually mature when extremely small in size and that males may possess well-developed testes containing free spermatozoa long before their chelipedes have reached the dimensions characteristic of large members of their sex. There is reason to believe that a precocious sexual development of this nature occurs in the case of *Palaemon rudis* in the Chilka Lake (*vide infra*).

In the specimens from Satpara the rostrum in both sexes is much more strongly upturned distally and the crest on the dorsal margin is less elevated than in the large females found at Barkul. The teeth are also rather larger proportionately and those on the upper margin are more evenly distributed, though those situated behind the one or two placed at the apex are in most cases separated by distinctly wider intervals than those near the rostral base. There are 11 or 12 dorsal and 5 or 6 ventral teeth; of the former three are situated on the carapace behind the level of the orbit.

The antennal scale is distinctly narrowed towards its distal end, thus differing from that of the larger specimens; in the chela of the first peraeopods there is a closer resemblance, but the fingers do not gape at the base when the claw is closed.

The length of the second peraeopods, in both males and females, is only about 70 % of the total length and the proportionate length of the ischium, merus, carpus,

palm and dactylus are approximately as 18, $18\frac{1}{3}$, 26, 17 and 15. The ischium, as Henderson and Matthai have shown, is as a rule proportionately longer in young (but not necessarily non-adult) Palaemonidae, than in full grown individuals. If allowance be made for this point it will be seen that the proportions are not strikingly different from those of large females. The segments bear small spinules precisely as in the large specimens.

A notable difference exists in the armature of the telson tip. In the Satpara specimens the inner pair of terminal spinules project far beyond the apex, whereas in large *P. malcolmsoni* they fall considerably short of it.

Whether the series from Satpara is correctly referred to *P. malcolmsoni* or not—and I am extremely doubtful of the accuracy of the determination—it is clear that it does not include any fully developed males and is therefore inadequate for a complete specific description. If the specimens are not young *P. malcolmsoni* they certainly cannot be identified with any other form known from Indian waters.

It will be noticed that in the specimens from Pondicherry, referred by Nobili to Heller's *P. danae*[1] and regarded by Henderson and Matthai as young *P. malcolmsoni*, there are fewer teeth on the lower border of the rostrum and no spinules on the segments of the second peraeopods.

The carapace of living examples from Satpara was dotted with chromatophores which formed definite spots laterally and an indefinite longitudinal dorsal streak. There was a conspicuous dorsal patch of white in the posterior part of the third abdominal somite and the legs were banded with maroon, with all the joints orange yellow and the dactyli of the last three pairs clear red. The chela of the second peraeopods and caudal fin were mottled with maroon and yellow pigment and the edges of the abdominal pleura were brown.

In the case of the large females from Barkul the legs were not banded, but had a purplish tinge. The margins of the abdominal pleura were usually bordered with pure white, but those of the last two segments were in some cases brown. There was no white patch on the third abdominal somite. The eggs in both cases were of an olivaceous tint.

The large females from Barkul were obtained when the water was quite fresh. The fact that, among numerous specimens examined, no large males were to be found, suggests that the females, as with *P. lamarrei*, may migrate to the lake when their eggs are ready to hatch.

The specimens of doubtful identity, obtained at Satpara, were found in water as salt as that of the Bay of Bengal near the mouth of the lake.

Palaemon rudis, Heller.

1910. *Palaemon rudis*, Henderson and Matthai, *Rec. Ind. Mus.*, V, p. 291, pl. xvii, figs. 5*a*—*h*.

Palaemon rudis is the commonest species of its genus in the Chilka Lake and is represented in our collection by a large number of specimens both young and adult.

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[1] Nobili, *Boll. Mus. Torino*, XVIII, No. 452, p. 7 (1903).

The teeth on the rostrum are more variable in number than is indicated in the description given by Henderson and Matthai. On the upper margin there are from 9 to 12 (usually 10 or 11) and on the lower margin from 3 to 5 (usually 4). In all cases the three posterior dorsal teeth are situated on the carapace.

The measurements of a series of males are shown below. Of these specimens, nos. 1—16 are fully developed,—that is to say, they have assumed the characters typical of large individuals of their sex. The second peraeopods or chelipedes are usually unequal in length and the larger of the two is nearly equal to, or considerably longer than, the total length; the segments are clothed with a fine velvety pubescence and tubercles are present on the fingers on either side of the cutting edge. With these features a well marked colour distinction is correlated, the chelipedes being dark blue-grey with a pale dorsal stripe.

Number.	Total length.	Length of carapace.	Length of right chelipede.	Length of left chelipede.	Larger chelipede : length of					Proportionate length of segments of larger chelipede to total length of chelipede (100) :				
					Ischium.	Merus.	Carpus.	Palm.	Dactylus.	Ischium.	Merus.	Carpus.	Palm.	Dactylus.
1	108	33·2	182	209	21·0	41·4	63·5	45·0	35·7	10·0	19·8	30·4	21·5	16·6
2	114	34·4	202	138	20·0	39·1	60·3	46·9	35·8	10·0	19·5	30·2	23·4	17·9
3	110	35·0	182	198	20·0	38·6	58·5	43·0	36·8	10·1	19·5	29·5	21·7	18·6
4	106	32·2	180	198	20·8	40·7	59·5	40·4	35·3	10·5	20·6	30·0	20·4	17·8
5	112	33·5	173	192	20·5	38·0	60·3	40·0	32·0	10·7	19·8	31·4	20·8	16·7
6	108	33·7	165	179	19·9	35·8	53·2	37·2	32·3	11·0	20·0	29·8	20·8	18·1
7	108	32·0	162	174	19·0	34·0	51·3	38·5	31·0	10·8	19·4	29·2	21·9	17·7
8	94	28·1	144	173	17·7	35·0	53·4	35·4	29·8	10·2	20·2	30·8	20·5	17·2
9	112	34·2	156	168	20·8	34·8	49·1	38·4	31·2	12·5	20·9	29·5	23·0	18·7
10	94	28·8	..	120	14·0	23·2	33·0	26·8	21·6	11·7	19·3	27·5	22·3	18·0
11	94	28·2	105	111	13·7	21·9	32·0	23·7	19·3	12·3	19·7	28·8	21·3	17·4
12	100	28·7	104	104	13·2	20·3	30·2	19·0	16·7	12·7	19·5	29·0	18·2	16·0
13	94	27·4	91	85	11·9	17·2	25·4	18·5	15·0	13·1	18·9	27·9	20·3	16·5
14	98	28·8	90	86	11·8	17·8	26·4	16·5	16·3	13·1	19·6	29·3	18·3	18·1
15	77	20·4	87·5	80	10·5	16·3	25·5	19·5	15·0	12·0	18·6	29·1	22·2	17·1
16	89	25·5	84	87·5	11·2	17·3	25·6	15·1	16·3	12·8	19·7	29·2	17·2	18·6
17	71	18·8	52·5	53·5	8·2	10·1	14·8	10·3	9·4	15·3	18·9	27·7	19·3	17·6
18	68	17·5	47·8	47·8	8·0	9·6	13·2	8·8	7·2	16·7	20·1	27·6	18·4	15·0
19	57	14·1	42·7	42·7	6·5	8·0	11·8	7·7	7·6	[illegible]	18·7	27·6	18·0	17·8
20	39·5	9·3	25·5	25·5	4·1	4·8	6·9	4·1	4·3	16·1	18·8	27·0	16·1	16·9
21	26·5	5·4	14·3	14·3	2·6	2·9	4·1	2·3	2·1	18·2	20·3	28·7	16·1	14·7
22	19·5	3·7	10·6	10·6	1·9	2·3	3·1	1·8	1·8	17·9	21·7	29·2	17·0	17·0
23	58·5	13·1	36·0	..	6·3	7·3	10·0	5·2	7·0	17·5	20·3	27·8	14·5	19·5
24	53	11·9	32·5	33·2	5·3	6·6	8·5	4·0	6·8	15·9	19·9	25·6	12·0	20·5
25	39	8·7	23·2	23·2	4·2	4·8	6·7	3·3	4·3	18·1	20·7	28·8	14·2	18·5
Average of specimens nos. 1—9 ..										10·6	20·0	30·1	21·6	17·7
,, ,, ,, nos. 11—16 ..										12·5	19·3	28·7	20·0	17·4
,, ,, ,, nos. 17—22 ..										16·6	19·7	28·0	17·5	16·5

In specimens nos. 17–22 the chelipedes are equal, or nearly so, and there are no tubercles on the fingers. In nos. 17 and 18 an inconspicuous pubescence, sparse and

very short, is to be seen on the carpus and palm, in the other specimens it is invisible.

As regards the proportions of the segments in specimens of different sizes, it will be seen from the averages of the percentage figures that the most noticeable change is that the ischium becomes proportionately shorter with increased size, *i.e.*, it grows much more slowly than the other segments. Henderson and Matthai have found that this takes place in several Palaemons and it probably occurs in the males of most species of the genus. In the case of *P. rudis* the disproportionate growth of this segment is counterbalanced by a considerable increase in the length of the palm and by a less considerable increase in the carpus and dactylus. The merus in its relative length remains practically constant during growth.

Judging from the collection made in the Chilka Lake, the greater part of the change in the proportionate lengths of the segments takes place suddenly. In males in which the chelipedes are decidedly shorter than the total length (specimens up to about 70 mm.) the proportions are similar to those of females. In larger individuals, in which the larger chelipede is equal to, or less than one and a half times the total length, notable differences are found; but the ischium is still proportionately larger (12·5 %) than in the largest examples—those in which the larger chelipede exceeds one and a half times the total length. From these facts it seems legitimate to infer that the change from the female type of limb to that characteristic of the fully grown male is, or may be, attained in two months.

A striking feature of the series of males from which the measurements given on p. 269 are derived, is that the appendix masculina is fully developed in all specimens except no. 22, in which it is rudimentary. As far as I am aware no precise observations have been made on the age at which this stylet becomes evident; but, from its intimate association with the sexual process, one would infer that it made its appearance only when the testes became functionally active. That it should be perfectly developed in specimens less than one quarter the maximum length of the species is most remarkable. Henderson and Matthai have already shown that a precocious sexual development may occur in at least some Palaemonidae, and it is probable that *P. rudis* affords an instance of the same phenomenon.

Three small males, nos. 23-25 of the series on p. 269, differ noticeably from any others in the collection in the great relative length of the dactylus. They differ in no other way from typical *P. rudis* of similar size, and I am inclined to regard them as abnormalites; it will be noticed that in normal specimens the dactylus is the most variable of all the segments of the chelipedes in its proportional length. It is possible that the great length of the fingers in these examples may indicate something more than an abnormality and that individuals with this character may be aggregated in certain localities to form a definite race; but at present we have no evidence that this is so.

The measurements of a series of females are shown on p. 271; of these all except the smallest (no. 11) bear eggs. The segments in their proportional lengths bear a close resemblance to those of young males and show but little change during growth;

a slight decrease in the relative length of the ischium is counterbalanced by an increase in the lengths of the palm and dactylus.

Number.	Total length.	Length of carapace.	Length of right chelipede.	Length of left cheli-pede.	Larger chelipede : length of					Proportionate lengths of segments of larger chelipede to total length of chelipede (100):				
					Ischium.	Merus.	Carpus.	Palm.	Dactylus.	Ischium.	Merus.	Carpus.	Palm.	Dactylus.
1	103	27·8	84	84	12·2	15·8	23·1	16·0	13·6	14·5	18·8	27·5	19·0	16·2
2	94	25·0	65·5	65·5	10·4	12·7	18·6	11·8	10·2	15·9	19·4	28·5	18·1	15·6
3	92	23·9	63	64	10·1	12·7	17·5	12·4	10·6	15·8	19·8	27·3	19·3	16·5
4	92	23·6	61	25	9·9	12·2	17·7	10·0	9·3	16·2	20·0	29·0	16·4	15·3
5	84	21·1	58	58	8·9	11·1	15·2	10·9	9·4	15·3	19·1	26·3	18·7	16·2
6	83	21·0	55·5	55·5	9·1	11·1	16·0	10·6	9·3	16·4	20·0	28·8	19·1	16·7
7	86	21·4	55·5	55·5	9·0	11·2	16·3	9·7	8·7	16·2	20·2	29·3	17·5	15·7
8	82	21·0	49	49	8·4	10·0	14·0	8·5	7·2	17·1	20·4	28·6	17·3	14·7
9	67	16·8	43	43	7·0	8·7	12·4	7·1	6·3	16·3	20·2	28·8	16·5	14·6
10	51	12·9	33	27	5·9	6·9	9·5	5·6	4·7	17·9	20·9	28·8	17·0	14·2
11	35·5	7·2	18·3	18·3	3·3	3·9	5·1	2·8	2·7	17·9	21·3	27·8	15·3	14·7
								Average	..	17·2	20·0	28·2	17·7	15·5

In life, females and young males differ noticeably in colour from adults of the latter sex. In young specimens and in females there is a pair of dark dorso-lateral streaks on the carapace and distinctive dark lateral markings. The first of these is situated on the gill-cover and is U-shaped with the anterior limb of the U turned forwards towards the base of the antennal scale. Behind this is another mark which is Γ-shaped and placed, not on the branchiostegite, but on the inner wall behind the gills. On the abdomen there is a faintly marked transverse patch at the end of the third abdominal somite and the margins of the pleura are dusky. The antennules are dull red and there is a conspicuous streak of reddish chromatophores up the middle of the antennal scale. All the legs are suffused with reddish-purple, the joints being tinged with orange yellow. The chelae of the second legs are not marbled as in the young individuals referred to *P. malcolmsoni*, and the fingers are reddish or colourless. The telson and uropods are stained with reddish-brown. In very large females the margins of the abdominal pleura are whitish and the claws of the second legs obscurely marbled with yellow. The distinctive colour markings on the carapace are faint or absent and there is, in general, a very marked resemblance to adult females of *P. malcolmsoni*.

Large males are of an almost uniform dull bluish or greenish-grey colour which becomes darker and has a mottled appearance on the telson and uropods. The antennules and antennae are grey and the scale is transparent in its external half, but possesses internally a broad dark grey longitudinal band. The second legs are dark bluish-grey, paler beneath and conspicuously mottled above with a very pale

grey. A broad and well defined pale streak extends along the dorsal surface of the merus, ischium and palm and is especially distinct on the last segment. The other legs are pale, slightly darker on the dactylus and at the distal end of the propodus.

Adults of both sexes of this species were found not uncommonly in the Chilka Lake in the months of September and November, when the water was fresh or very slightly brackish. During the former month they were obtained in abundance at Barkul, where they are trapped in large numbers by the fishermen. Specimens were also found off Nalbano, near Barnikuda I., and in the vicinity of Arupatna in the outer channel. In the last locality they were found on the banks among submerged roots of screw-pines. The females found at this season of the year were bearing eggs.

No adults of either sex were found at any other time of the year; but young individuals were frequently met with in February and March round the rocks at the foot of Ganta Sila, at Chiriya I. and at Barkul Point, in water of moderate salinity (sp. gr. 1·009—1·011), and in the latter month were abundant at Satpara in water as salt as that of the Bay of Bengal near the lake (sp gr. 1·0265).

We are convinced that in this species—and the facts already brought forward in reference to *P. malcolmsoni* tend to show that the same is the case with it also—the prawns, when they have attained a certain size, leave the lake and, during the monsoon, resort to the flooded rice-fields and other bodies of fresh water to which ingress is easy. In the freshwater season, probably that of the following year, they return to the lake when the eggs of the females are ripe. At this period, in the case of *Palaemon rudis*, adult males accompany the females, whereas in *P. malcolmsoni* it is apparently only the latter sex that visits the lake at the breeding season. In the last species impregnation of the ova probably takes place outside the lake before the annual migration of the females has begun.

Palaemon rudis is known from E. Africa, Mozambique, Madagascar and Ceylon. The species is not uncommon in the vicinity of Calcutta and is recorded by Henderson and Matthai from Coconada and Madras.

Palaemon scabriculus, Heller.

1910. *Palaemon scabriculus*, Henderson and Matthai, *Rec. Ind. Mus.*, V, p. 296, pl. xvii, figs. *7a-c*, pl. xviii, figs. *7a-p*.

To this species I refer two specimens caught by fishermen near Rambha at the south end of the lake. One of them, in which there is a marked inequality in the second pair of legs, is, I believe, a young male; the appendix masculina, however, is not developed and the large chelipedes only bear scanty hairs in place of the dense felted coating found in adults. The other individual is a female.

In the female the rostrum bears twelve teeth above and two beneath and reaches a little beyond the end of the antennular peduncle. In the male there are thirteen dorsal teeth and two ventral, the blade reaching only to the end of the peduncle. The four proximal dorsal teeth, in both cases, are situated on the carapace behind the orbit.

The specimens yield the following measurements (in mm.):—

Sex.	Total length.	Length of carapace.	Length of right chelipede.	Length of left chelipede.	Larger chelipede: length of				
					Ischium.	Merus.	Carpus.	Palm.	Dactylus.
♀	54	14·4	33	31·5	5·2	6·7	7·0	6·8	5·8
♂	47·8	12·0	26·3	30·6	4·7	6·3	6·1	6·8	5·4

P. scabriculus must be regarded merely as an occasional visitor to the lake. It is evidently very scarce and there is little likelihood that it ever breeds in the water near Rambha which, throughout the year, retains some trace of salinity. At the time the specimens were obtained the specific gravity of the water in this neighbourhood was 1·011.

Other references to *P. scabriculus* will be found in the paper cited above. The species is common in S. India and is known from Kotri on the R. Indus and from Pondicherry. It has also been recorded from Ceylon, from Saleyer and from Celebes.

Genus LEANDER, Desmarest.

Leander styliferus (Milne Edwards).

1837. *Palaemon longirostris*, Milne-Edwards, *Hist. nat. Crust.*, II, p. 394 (not *P. longirostris*, *ibid.*, p. 392).

1840. *Palaemon styliferus*, Milne-Edwards, *Hist. nat. Crust.*, III, p. 638 (*nom. nov.* for *P. longirostris*, *loc. cit. supra*, p. 394).

1893. *Leander longirostris*, Henderson, *Trans. Linn. Soc., Zool.* (2), V, p. 439.

1902. *Palaemon styliferus*, Rathbun, *Proc. U.S. Nat. Mus.*, XXVI, p. 51.

1908. *Leander* sp., de Man, *Rec. Ind. Mus.*, II, p. 220, pl. xviii, fig. 3.

The single specimen of this species found in the Chilka Lake is a non-ovigerous female 62 mm. in total length: it agrees closely with Henderson's description. The basal crest of the rostrum bears six teeth and there are two other dorsal teeth near the apex; on the lower margin are eight teeth. The mandibular palp, as in the genus *Palaemon*, is composed of three segments.

The specimens recorded by de Man from Amoy in China [1] appear to be distinct from this species. Apart from the differences noted by de Man in the proportions of the branchiostegal and antennal spines (explained by Henderson as a clerical error in the description), the short filament of the antennules is much longer in the Chinese specimens and the second peraeopods considerably shorter. These legs in large individuals from the Gangetic Delta reach beyond the antennal scale by the whole length of the carpus and chela and, in smaller specimens, by at least the entire length of the chela. The fingers in Indian examples are always much longer than the palm.

[1] De Man, *Notes Leyden Mus.*, III, p. 141 (1881).

The forms described by Ortmann[1] under the names *Leander longirostris* var. *japonicus* and var. *carinatus* are now regarded as distinct species.[2] The specimens recorded by de Man (*loc. cit.*) under the name *Leander* sp. are almost certainly young examples of *L. styliferus*.

Leander styliferus is extremely common in brackish water in the Sunderbuns and the Gangetic delta, the locality from which the original specimens described by Milne-Edwards were obtained. It is also recorded by Henderson and Miss Rathbun from Karachi and by the former author from Mergui and the Gulf of Martaban.

The species is evidently nothing more than a casual visitor to the Chilka Lake. The single specimen obtained was found at Satpara in March 1914, in water of the same salinity as that of the Bay of Bengal in the vicinity.

Genus UROCARIS, Stimpson.

1860. *Urocaris*, Stimpson, *Proc. Acad. Nat. Sci. Philadelphia*, XII, p. 39.
1902. *Urocaris*, Rathbun, *Bull. U.S. Fish Comm. for* 1900, XX, ii, p. 126.

Urocaris is one of the genera which lie on the border-line between the Pontoniidae and Palaemonidae, families which until recently have been regarded as distinct. The absence of a palp on the mandible and the rather deeply cleft outer antennular flagellum induced most authors to regard it as an ally of *Palaemonetes*, but Sollaud[3] has very correctly pointed out that the reduced gill-formula and the presence of three pairs of spines at the apex of the telson indicate a position near *Periclimenes* and other less specialized genera of the old Pontoniidae.

In the species of *Urocaris*, found in the Chilka Lake, the branchial formula is as follows:—

	VII	VIII	IX	X	XI	XII	XIII	XIV
Exopods ..	1	1	1	..	..	..	..	..
Podobranchs ..	ep.	ep.	ep.	..	..	..	..	..
Arthrobranchs ..	..	..	1	..	..	..	..	..
Pleurobranchs ..	..	..	..	1	1	1	1	1

This formula is almost identical with that found in *Periclimenes*, from which, however, *Urocaris* may be separated by the more deeply cleft outer antennular flagellum and by the great length of the last abdominal somite. In *Urocaris*, also, the inferior portion of the rostrum, *i.e.* that situated below the midrib, is ill-developed or absent and ventral teeth, if present, are placed close to the apex. These characters are not very convincing, though, in combination, they give the typical species of the genus a very distinct facies.

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[1] Ortmann, *Zool. Jahrb., Syst.*, V, pp. 519-521, pl. xxxvii, figs. 14, 14z.
[2] See Rathbun, *loc. cit.*, and Doflein, *Abhandl. k. bayer. Akad. Wiss.*, XXI, p. 639, pl. iii, fig. 8 (1902).
[3] Sollaud, *C. R. Acad. Sci., Paris*, Dec., 1910, p. 1.

In *U. longicaudata*, Stimpson, the type species of the genus, and in its two near allies, *U. infraspinis*, Rathbun, and *U. indica*, described below, the dactyli of the last three peraeopods bear a slender inferior spine, thus differring notably from all *Periclimenes*. In the two other described species of *Urocaris*, *U. longipes*, Stimpson, and *U. psamathe*, de Man, forms which differ widely from the more typical representatives of the genus, the dactyli are stated to be unarmed. In *U. psamathe* the mandible has apparently not been examined and in both species we lack information regarding the branchial formula.

Urocaris indica, sp. nov.

(Plate XIII, fig. 9.)

? 1905. *Urocaris longicaudata*, Pearson (*nec* Stimpson), *Rep. Pearl Oyster Fisheries, Ceylon*, IV, p. 78, pl. i, figs. 5, 5*a*.

The rostrum reaches almost to the end of the antennular peduncle. The upper portion of the blade, that is to say that situated above the midrib, is deep and forms a strongly arched crest rising above the general level of the carapace and armed with 8, 9 or 10 more or less evenly spaced teeth.[1] The first of these teeth is situated a little behind the orbit, while the second is immediately above it. The crest is continued backwards as a well-marked carina for two-thirds the length of the carapace and bears, a little in front of the middle point of the latter, a single isolated spine. The portion of the rostral blade below the midrib is obsolete and the lower edge is, in consequence, straight or even a trifle concave. This margin is unarmed throughout the greater part of its length; but, close to the apex and below, or in front of the most distal tooth of the dorsal series, bears from 1 to 3 (usually 2) minute teeth (pl. xiii, fig. 9).

The carapace, except for the median carina noticed above, is smooth. It is provided with sharp antennal and hepatic spines and the sub-orbital angle is narrowly produced and rounded at the extremity.

The eyes are rather long, reaching almost to the end of the basal antennular segment; they possess a well-defined ocellus.

The lateral process of the antennular peduncle (text-fig. 26*a*) has the form of a sharp external spine situated at the proximal end. The outer margin in front of this process is convex; it bears a strong spine anteriorly and is continued forwards beyond this to a point much in advance of the insertion of the second segment. The extreme length of the basal segment is about twice that of the two following combined. The outer antennular flagellum is distally divided into two unequal rami, the inner long and slender, the outer stout and, including the basal fused portion, of a length equal to that of the peduncle. The length of the stout outer branch is variable, but usually less than half that of the fused portion.

The antennal scale (text-fig. 26*b*) reaches only a trifle beyond the antennular peduncle. It is from three and a third to three and three quarter times as long as

[1] In one wholly abnormal specimen there are only five dorsal teeth.

wide and the broad but rather sharply angled apex of the lamella extends beyond the spine which terminates the straight outer margin for a distance not greater than the length of the spine.

The mandible is without palp; the incisor process terminates in three teeth. The epipod of the first maxillipede is a little emarginate but is not bilobed. The exopod of the third maxillipede reaches about to the end of the antepenultimate segment, which is furnished with a variable number of spinules on its outer margin. The ultimate segment is about two-thirds the length of the antepenultimate.

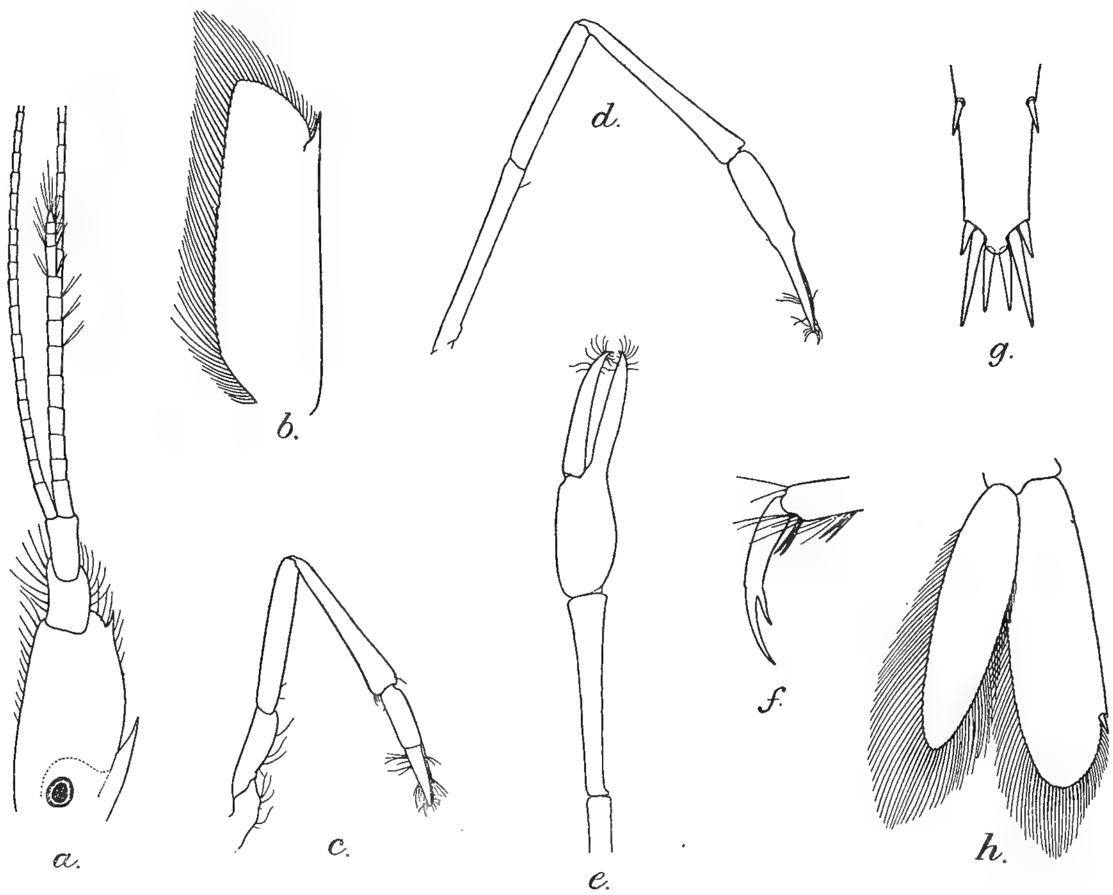

FIG. 26.—*Urocaris indica* sp. nov.

a. Antennule.
b. Antennal scale.
c. First peraeopod.
d. Second peraeopod.
e. Carpus and chela of 2nd peraeopod from above.
f. Dactylus of fifth peraeopod.
g. Apex of telson.
h. Uropods.

The first peraeopods (text-fig. 26*c*) reach to two-thirds the length or almost to the apex of the antennal scale. The merus and carpus are of equal length and about one sixth longer than the chela. The dactylus is equal in length to the palm and there are a few tufts of setae on the fingers, at the base of the palm and at the distal end of the carpus.

The second peraeopods (text-figs. 26*d*, *e*) reach beyond the end of the scale by the length of the fingers and sometimes by almost the entire length of the palm as well. The lengths of the segments (in mm.) of seven specimens are as follows:—

Sex.	Second peraeopod : length of				
	Ischium.	Merus.	Carpus.	Palm.	Dactylus.
♀	1·8	1·4	1·75	·9	1·0
♀	1·5	1·2	1·4	·7	·7
♀	1·5	1·0	1·4	·7	·8
♀	1·4	1·1	1·4	·8	·9
♀	1·3	1·1	1·4	·7	·8
♂	1·2	·9	1·2	·6	·65
♂	1·0	·7	1·0	·4	·4

The fingers are provided with inturned claws and with a few setae placed distally, but are without teeth on the cutting margins. There are no spines on any of the segments.

The third peraeopods reach almost or quite to the end of the antennular peduncle; those of the fifth pair are a little longer. In all the last three pairs the posterior margins of the propodi bear tufts of longish setae and the dactylus is naked and biunguiculate, bearing a slender spine near the apex (text-fig. 26*f*). In those of the fifth pair the ischium and carpus are of equal length; the carpus is a little more than half the length of the merus and a little less than half the length of the propodus; the latter segment is rather less than four times as long as the dactylus.

The abdominal somites are smooth; the third is somewhat strongly arched in lateral view and overhangs the succeeding somite. The sixth somite is about twice the length of the fifth and is a little longer than the telson.

Both uropods extend beyond the apex of the telson, the outer being the longer and about three and a half times as long as broad (text-fig. 26*h*). The telson is narrow with two pairs of dorso-lateral spinules. The apex (text-fig. 26*g*) is produced in the middle to a bluntly rounded lobe and bears three pairs of spinules. The tips of the inmost pair fall only a little short of those of the intermediate pair, the outermost being much the shortest.

Large ovigerous females reach a length of nearly 16 mm.

Urocaris indica is very closely allied to *U. infraspinis*, Rathbun[1], from California and the Pacific coast of Mexico. It agrees with this species and differs from *U. longicaudata*, Stimpson[2], the type of the genus, in possessing an antennal spine and a well defined ocellus at the base of the cornea. The characters separating *Urocaris infraspinis* from the form found on the Indian coasts appear to be as follows :—

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[1] Rathbun, *Proc. U. S. Nat. Mus.*, XXIV, p. 903 (1902) and *Harriman Alaska Exped.*, X, p. 31, text-figs. 10*a*, *b* (1910).

[2] This species, examples of which I have examined, is recorded from the West Indies and the adjacent eastern coast of America. See Stimpson, *Proc Acad. Nat. Sci. Philadelphia*, XII, p. 39 (1860) and Rathbun, *Bull. U.S. Fish Comm. for* 1900, XX, ii, p. 126 (1902).

U. infraspinis.	*U. indica.*
Rostrum slightly shorter, with 5-7 teeth above[1] and 1 or 2 below.	Rostrum slightly longer, with 8-10 teeth above[1] and 2 or 3 below.
Basal segment of antennular peduncle narrower, its outer margin nearly straight.	Basal segment of antennular peduncle broader, its outer margin convex.
Apex of antennal scale produced far beyond the spine which terminates the outer edge.	Apex of antennal scale produced not so far beyond the spine which terminates the outer edge.
Second peraeopods with merus and ischium subequal; palm a little shorter than ischium.	Second peraeopods with merus decidedly shorter than ischium; palm little, if at all, more than half the length of ischium.
Sixth abdominal somite less than twice as long as fifth.	Sixth abdominal somite twice as long as fifth.
Size larger, up to about 21 mm.	Size smaller, not more than 16 mm.

Some of these distinctions would perhaps break down on actual comparison of specimens, while others, possibly of greater value, might be found.

With the two remaining described species of *Urocaris*, *U. longipes*, Stimpson[2] and *U. psamathe*, de Man[3], the Indian form has little in common.

I think it very probable that the specimen recorded by Pearson (*loc. cit.*) under the name *U. longicaudata*, Stimpson, from the Ceylon Pearl Banks should be referred to this species. In the Indian Museum are numerous examples of *U. indica* obtained at the north end of the Gulf of Manaar, a locality not far distant from the Pearl Banks, and these are indistinguishable from individuals found in the Chilka Lake. The fact that an antennal spine was present in Pearson's example clearly indicates that it was incorrectly referred to the West Indian species; in the figures, however, no ocellus is shown and the rostrum is less elevated than in any example of *U. indica* that I have seen.

Examined when alive, specimens of *Urocaris indica* are almost perfectly transparent to the naked eye, but under a lens small speckles of white arranged in transverse rows are seen on the abdomen, at the tip of the telson, on the uropods and on the eyestalks. There are also minute maroon specks on the carapace and abdomen, the amount of pigmentation present varying greatly in different individuals. The eggs borne by the females are sage green in colour.

This species is very common in the Chilka Lake, especially near the shores among weeds. It is extremely abundant at the south end of the lake and at Barkul and is equally common at localities near the inner end of the outer channel, where the bottom is composed of muddy sand and weed is plentiful. The species is able to tolerate extreme variations in salinity, having been found in water that was quite fresh as well as in that which was as salt as the Bay of Bengal near the lake.

Ovigerous females were found in February, March, July and September. In the latter month, however, egg-bearing individuals were obtained only at the south

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[1] Excluding the tooth situated on the carapace behind the rostrum.

[2] Stimpson, *Proc. Acad. Nat. Sci. Philadelphia*, XII, p. 39 (1860).

[3] De Man, *Abhandl. Senckenb. naturf. Ges., Frankfurt*, XXV, p. 816, pl. xxv, fig. 51 (1902),

end of the lake in water which was slightly brackish; no ovigerous specimens were seen out of many collected during this month at other localities in fresh water, and it appears that the species breeds only in water containing some trace of salinity.

In addition to a long series from the Chilka Lake, there are in the Indian Museum specimens of *U. indica* found by Dr. Annandale at Ennur and in the Adyar R. near Madras, and others which I myself obtained living in pure sea-water inside the fringing coral-reef at Kilakarai at the northern end of the Gulf of Manaar. The specific gravity of the water in which specimens were taken at Ennur in January 1915, varied from 1·000 to 1·0045; the collection includes numerous ovigerous females, but there had been a sudden inflow of fresh water, abnormal at that time of year, just previous to their capture.

The type specimens bear the number 8997-8/10 in the Indian Museum register.

Genus **PERICLIMENES**, Costa.

1852. *Anchistia*, Dana, *U. S. Explor. Exped., Crust.*, I, p. 577.
1898. *Periclimenes*, Borradaile, *Ann. Mag. Nat. Hist.* (7), II, p. 380

Periclimenes demani, sp. nov.

(Plate XIII, fig. 10.)

The carapace is smooth with broadly rounded antero-lateral angles. Supra-orbital and hepatic spines are present, the latter being placed a little below the level of the antennal spine.

The rostrum, in the female, reaches almost or quite to the apex of the antennal scale, sometimes a little beyond it in the male; in lateral view the blade is broad in front of its middle point and is very slightly upturned towards the apex. On the upper edge there are 7 to 9 teeth and on the lower 1 to 3; in nearly all the specimens there are 8 or 9 above and 2 or 3 below. The proximal tooth is remote from the rest of the series and is situated on the carapace at the junction of the middle and anterior thirds of its length. The second tooth is placed over the orbit and from this onwards the teeth are, as a rule, regularly spaced; the distal tooth is usually situated close to the apex (pl. xiii, fig. 10).

The cornea of the eye is a trifle wider than the stalk and in the female is, as in some allied species, traversed by a dark band. The band commences near the ocellus —which in this species is conspicuous—and extends round the inner half of the cornea, meeting the stalk again on its ventral side.

The antennular peduncle (text-fig. 27*a*) extends to about two-thirds the length of the antennal scale. The broad basal segment is more than one and a half times the length of the second and third segments combined; its outer margin is furnished proximally with a spine-like lateral process and terminates in a stout tooth; the margin inwards of this tooth is strongly sinuous and is bordered with setae. The outer flagellum is unequally bifid distally and the thickened part (*i.e.* the fused portion, composed of 12 to 14 segments, + the stouter and shorter of the two terminal

branches) extends beyond the apex of the antennal scale by two-thirds of its length in the male, by a little less in the female.

The antennal scale (text-fig. 27*b*) is about three and three quarter times as long as broad in large females, about four and a half times as long as broad in males. The outer margin is nearly straight in the female, a little concave in the male, and terminates in a spine which reaches to, or a trifle beyond, the apex of the lamella; the apical portion of the latter is not strongly narrowed as in *P. ensirostris* (Dana).

The mandible is without palp. The molar process is trilobed terminally and the incisor process ends in three sharp teeth.

The outer maxillipedes reach to the end of the antennal peduncle. The ante-

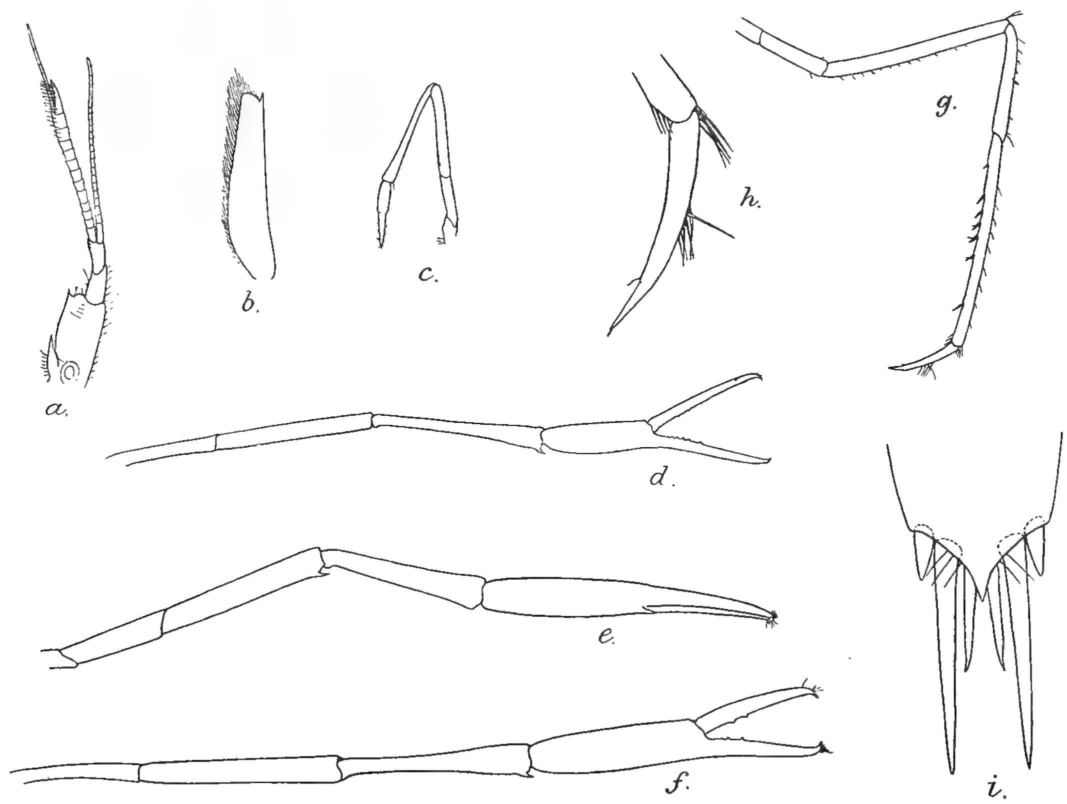

FIG. 27.—*Periclimenes demani*, sp. nov.

a. Antennule.
b. Antennal scale of male.
c. First peraeopod.
d. Second peraeopod of male from L. Chilka.
e. Second peraeopod of female from L. Chilka.
f. Second peraeopod of female from Madras.
g. Fifth peraeopod.
h. Dactylus of fifth peraeopod.
i. Apex of telson.

penultimate segment is exceeded in length by the exopod and its outer margin is as a rule bare, without spinules or setae. The ultimate segment is about three quarters the length of the penultimate.

The first peraeopods (text-fig. 27*c*) reach a trifle beyond the antennal scale. The carpus is about one-fifth longer than the merus and nearly twice the length of the chela. The palm is a little shorter than the fingers and bears on its inner face numerous setae arranged in transverse rows. The fingers also bear a few tufts of setae on their margins and are without teeth on the cutting edge.

The second peraeopods (text-figs. 27*d*, *e*, *f*) are equal. In the female they extend beyond the apex of the antennal scale by the length of the chela, or, in very large

individuals, by the length of the chela and half the carpus. In the male they are decidedly longer proportionately, reaching beyond the scale by the chela and two-thirds the length of the carpus. The limbs of five separate specimens yield the following measurements[1] (in mm.) :—

Sex.	Second peraeopod : length of				
	Ischium.	Merus.	Carpus.	Palm.	Dactylus.
♂	2·2	3·2	3·2	2·0	2·1
♂	2·0	2·9	3·0	1·9	2·1
♀	2·1	3·2	3·3	2·4	1·8
♀	2·0	2·7	2·7	2·2	1·5
♀	2·0	2·6	2·7	2·1	1·6

It will be seen that the merus and carpus are about equal in length and that the latter segment is considerably longer in the male than in the female and in the former sex is conspicuously longer than the palm. The fingers in the male are a little longer than the palm, while in the female they may be less than three-quarters its length. There is a spine at the distal end of the merus, situated inferiorly, and one at the distal end of the carpus, placed internally. There are a few very small teeth, sometimes as many as six, on the inner half of the fixed finger and others, still more minute, similarly placed on the dactylus.

The third, fourth and fifth pairs of peraeopods reach to, or a little beyond, the apex of the antennal scale. In those of the fifth pair (text-fig. 27*g*) the propodus is a trifle longer than the merus, about twice the length of the carpus and nearly three times the length of the dactylus. The propodus bears setae at its distal end and five or six spinules on the inner border; the dactylus is slender, slightly curved and with a few setae in the middle of its outer margin.

The only gills which are well developed are the five pleurobranchs. The pleurobranch found in *Palaemon* at the base of the third maxillipedes is absent, while the arthrobranch of the same segment is represented only by a few lamellae. There is, apparently, no trace of a podobranch on the second maxillipede.

There is a marked difference between the sexes in the form of the pleopods. In the male the protopodite is about equal in length to the exopod, whereas in the female it is proportionately half as long again. The greater length of the segment in the latter sex is correlated with the greater depth of the abdominal pleura; it is doubtless a provision to enable the pleopods to have free play when the female is heavily laden with eggs.

The abdominal somites are smooth; the sixth is little more than half the length

[1] These measurements are taken from specimens found in the Chilka Lake. In ovigerous females from the neighbourhood of Madras, which are of considerably larger dimensions, and in a few examples from the Chilka lake (text-fig. 27*e*) the palm is a little longer proportionately, about equal in length with the carpus and merus. In a male from Madras the proportional lengths of the segments of the second leg are much as in the Chilka specimens, but the limb is longer, reaching beyond the apex of the scale by the chela and the whole length of the carpus.

of the telson (terminal spines included). The outer and inner uropods are equal in length, the former being about two and a fifth times as long as broad. The telson bears two pairs of dorso-lateral spinules and is not sulcate above; the apex (text-fig. 27*i*) is sharply acute and is furnished with three pairs of spines, those of the intermediate pair twice, or more than twice, the length of the inner and several times longer than the outer.

Eyed eggs borne by females are about 0·58 mm. by 0·44 mm. in longer and shorter diameters.

Large specimens from the Chilka Lake do not exceed 21 mm. in total length; individuals from the Madras backwaters are frequently larger, up to 25 mm. in length.

The presence of supra-orbital and hepatic spines and the long and slender carpus of the second peraeopods, outstanding characters of *P. demani*, are shared by six described representatives of the genus; namely—

Periclimenes aesopius (Bate).

1863. *Anchistia aesopia*, Bate, *Proc. Zool. Soc., London*, p. 502, pl. xli, fig. 5.

Periclimenes danae (Stimpson), Borradaile.

1898. *Periclimenes danae*, Borradaile, *Proc. Zool. Soc., London*, p. 1004, pl. lxiii, figs. 4, 4*a*, *b*.

Periclimenes edwardsi (Paulson).

1875. *Anchistia edwardsii*, Paulson, *Crust. of the Red Sea*, p. 114, pl. xvii, figs. 2, 2*a*, *b*.
1906. *Anchistia edwardsi*, Nobili, *Ann. Sci. nat., Paris*, (9), iv, p. 53.

Periclimenes elegans (Paulson).

1875. *Anchistia elegans*, Paulson, *ibid.*, p. 113, pl. xvii, figs. 1, 1*a-h*.
1906. *Anchistia elegans*, Nobili, *ibid.*, p. 52.

Periclimenes ensifrons (Dana) [=*P. vitiensis*, Borradaile and ? *P. grandis* (Stimpson)].

1852. *Anchistia ensifrons*, Dana, *U.S. Explor. Exped., Crust.*, I, p. 578, pl. xxxvii, figs. 5*a-l*.
1902. *Periclimenes ensifrons*, de Man. *Abhandl. naturf. Ges. Frankfurt*, XXV, p. 826.

Periclimenes tenuipes (Holmes *nec* Borradaile).[1]

1900. *Anchistia tenuipes*, Holmes, *Occas. Papers California Acad. Sci.*, VII, p. 216.
1910 *Periclimenes tenuipes*, Rathbun, *Harriman Alaska Exped.*, X, *Crust.*, p. 34, text-fig. 12.

P. aesopius is readily distinguished from *P. demani* by the form of the third abdominal somite which is "postero-dorsally carinated and elevated into a hump-like tooth." From all the other species listed above *P. demani* may be distinguished

[1] I am unable to understand Nobili's statement (*Ann. Mus. Zool. Napoli*, II, 1907, No. 21, p. 5) that Heller regarded *Palaemon biunguiculatus* as a synonym of "*Periclimenes tenuipes*, Leach." Heller in 1857 (*Crust. südlich. Europ.*, p. 256) cites *P. unguiculatus* as a synonym of *Anchistia scripta*; but there is no reference to any species of Leach and I am unable to discover that that author ever described a Palaemonid under the name of *Periclimenes tenuipes*. If this is so, *tenuipes* may legitimately be used for the Californian species described by Holmes, while *P. borradailei*, Rathbun (1904) should be employed for *P. tenuipes*, Borradaile. Nobili (*Bull. sci. France Belg.*, XL, 1906, p. 42) has suggested the name *brevinaris* for the form which he described in the preceding year (*Bull. Mus. d'Hist. Nat., Paris*, 1905, p. 159) as *P. borradailei*.

by the greater length of the carpus of the second peraeopods which, even in the female, is as long or longer than the palm.

In addition it differs notably from *P. ensifrons* and *P. elegans* in the form of the antennal scale, which in those species is concave externally and terminates in a spine which far outreaches the narrow apex of the lamella. *P. danae*, as identified and figured by Borradaile, has three posterior rostral teeth situated on the carapace and the ultimate segment of the outer maxillipedes (according to the figure) only about half the length of the penultimate. In *P. edwardsi* two posterior rostral teeth are placed on the carapace and the antennular peduncle is longer, reaching the apex of the antennal scale.

In the scheme of classification recently proposed by Borradaile[1] *P. demani* apparently finds a place in the subgenus *Falciger*.

Periclimenes demani, when alive, is transparent, speckled with greenish-yellow chromatophores. A dark brown stripe is conspicuous in lateral view on either side of the mouth and another similar stripe in front of the first pair of legs. The rostrum, antennules and antennae are transparent with occasional greenish-yellow chromatophores. The legs are entirely transparent, except for the fingers of the large claw which are bluish, and for a suffusion of bright orange yellow at the junction of the fingers and palm of the same limb. On the thoracic sternum is a broad transverse maroon band which involves the basal segments of the third legs. The margins of the abdominal pleura and uropods are mottled with maroon and the eggs are sage green.

The species is not uncommon in the Chilka Lake, though much less abundant than *Urocaris indica*. Unlike the latter form it is entirely absent from the main area of the lake. It has been found in numerous localities in the outer channel, living among weeds in quite shallow water; it has been taken off Barnikuda I., in Seruanaddi, at Satpara, near Mahosa, and, in the flood season, among submerged vegetation near Manikpatna.

The species appeared to be equally abundant both in March, where the water was of the same salinity as that of the sea outside the lake and in September when it was quite fresh. In March the breeding season was just beginning, a few females bearing eggs that were not eyed; by September it was apparently almost over, or a second breeding period was almost completed, for the eggs borne by the single ovigerous female that was then obtained were fully eyed and on the point of hatching.

The specimens from the neighbourhood of Madras, where the species appears to be commoner than in the Chilka Lake, are, as already noted, of a larger size than those found in the Chilka Lake. They were obtained by Dr. Annandale in October 1913, in the Adyar River in water that was almost fresh, and also in the Ennur backwater in January 1915, in water of specific gravity varying from 1·000 to 1·0045. On both occasions ovigerous females were taken.

The type specimens bear the number 8981-4/10 in the Indian Museum register.

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[1] Borradaile, *Ann. Mag. Nat. Hist.* (8), XV, p. 207 (1915).

Family ALPHEIDAE.

Five species of Alpheidae occur in the Chilka Lake, but only two of them, *Alpheus crassimanus* and *A. paludicola*, inhabit the main area. All of them are able to exist in pure fresh water as well as in water as salt as that of the Bay of Bengal in the vicinity of the lake. The species of *Athanas* is remarkable for the existence in the males of a well-marked trimorphism.

Genus **OGYRIDES**, Stebbing.

1860. *Ogyris*, Stimpson, *Proc. Acad. Nat. Sci. Philadelphia*, XII, p. 36.
1899. *Ogyris*, Coutière, *Ann. Sci. nat., Zool.* (8), IX, p. 332.
1911. *Ogyris*, de Man, *Decap. 'Siboga' Exped.*, II, Alpheidae, p. 135.
1914. *Ogyrides*, Stebbing, *Ann. S. African Mus.*, XV, p. 31.

The name *Ogyrides* has recently been proposed by Stebbing in substitution for Stimpson's *Ogyris*, preoccupied by Doubleday (1847) in Lepidoptera.

The genus is extremely abnormal in type, exhibiting in the feeble dimensions of the first peraeopods a condition which is in all probability primitive, while the attenuated eyestalks, the form of the antennular peduncle and antennae, the great length of the exopods of the first two pairs of maxillipedes and the reduced branchial formula are indications of extreme specialization. The relationship of *Ogyrides* with more typical Alpheidae is traced through *Automate*, a genus in which the antennular peduncle and antennal carpocerite are of great length and in which, as in *Ogyrides*, the eyes are not concealed.

The branchial formula of the species of *Ogyrides* found in the Chilka Lake is as follows:—

	VII.	VIII.	IX.	X.	XI.	XII.	XIII.	XIV.
Podobranchs ..	ep.	ep.	ep.	..	..	..	..	..
Arthrobranchs ..	..	..	..	..	..	..	..	..
Pleurobranchs ..	..	..	..	1	1	1	1	1

The branchiae are fewer in number than in any other genus of Alpheidae; but, except for the absence of an arthrobranch at the base of the third maxillipede, the formula resembles that found in *Cheirothrix* and *Synalpheus*.[1]

The single species of this genus found in the Chilka Lake appears to find its nearest ally in a form recorded from the mouth of the Tocantins River in Brazil.

Ogyrides striaticauda, sp. nov.

The rostrum is flat and triangular and slightly curved downward distally; it scarcely reaches beyond the infero-orbital angle of the carapace (text-figs. 28*a*, *b*). The apex is acute and the margins are furnished with setae. Behind it the carapace is keeled in the mid-dorsal line for nearly half its length, the carina bearing a series of

[1] *Cf.* Coutière, *Ann. Sci. nat., Zool.* (8), IX, p 276 *et seq.* (1899).

from 7 to 9 forwardly directed teeth. On either side the carapace is rather thickly clothed with plumose setae. A cervical groove (*e* of Boas' terminology) is distinct, the orbits are semicircular, the infero-orbital angle bluntly rounded and the pterygostomian obtusely pointed.

The eyes are very long and slender and extend beyond the antennular peduncle for a distance equal at least to the length of the last segment of the latter. The stalks are broad at the base, but very narrow in the middle, expanding slightly at the distal end. Each bears a row of setae on the inner margin towards the end of the proximal third of its length.

The basal segment of the antennular peduncle reaches to half the length of the

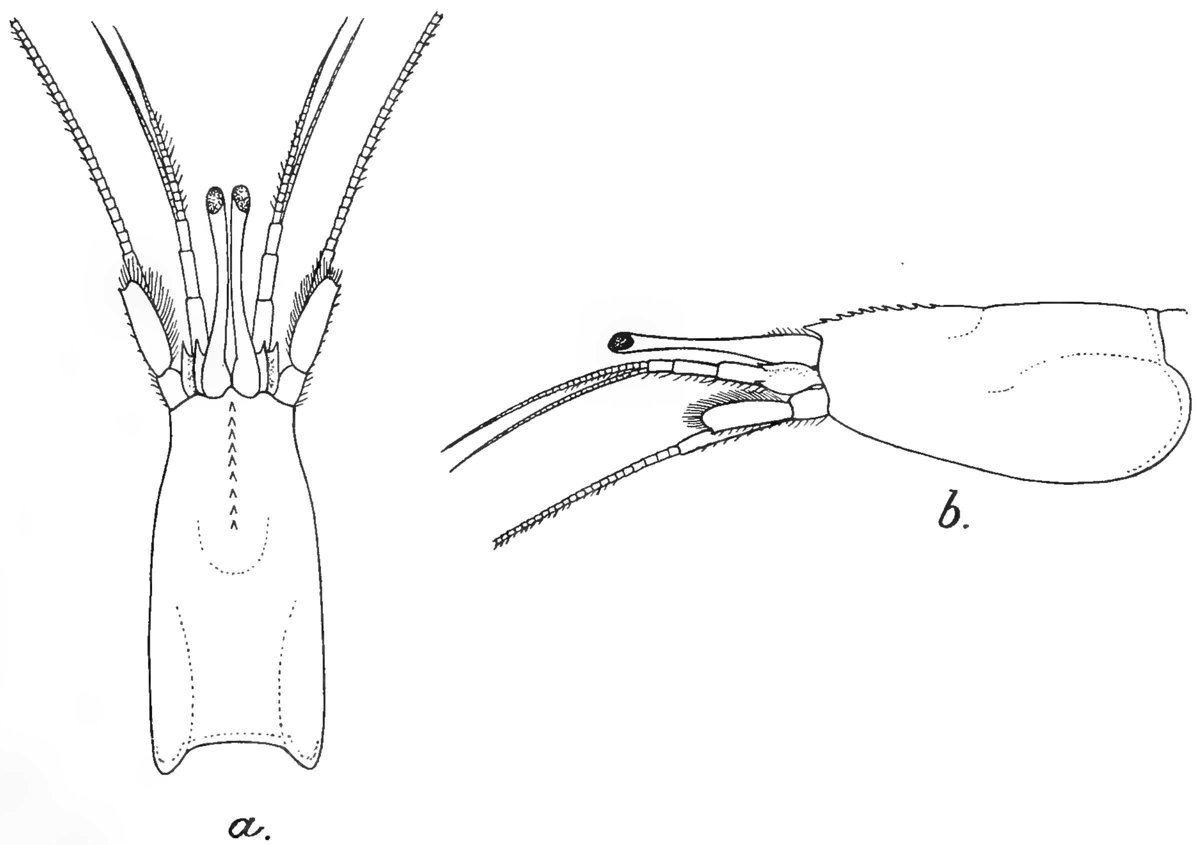

FIG. 28.—*Ogyrides striaticauda*, sp. nov.
Carapace and anterior appendages. *a.* Dorsal view. *b.* Lateral view.
The fine setae on the carapace are not shown.

eyestalks. The lateral process has two ridges, the lower, which corresponds to the outer margin of the process in normal forms and the upper, which is nearly vertical and lies close to the outer edge of the eyestalk. Each of these ridges terminates anteriorly in a strong spine; the tips of the spines are on a level and reach to about three fifths the length of the segment. The second segment of the peduncle is rather more than half the length of the first and the third about half the length of the second. The flagella are of the same length, about as long as the peduncle.

The basicerite of the antenna bears a single external spine; the carpocerite is very long, reaching to the last segment of the antennular peduncle. The antennal scale reaches only to the middle of the second segment of the peduncle; it is about

three and a quarter times as long as wide and the outer margin is straight terminating in a spine which reaches almost to the apex of the lamella.

The mouth parts are illustrated in text-figs. 29*a-f*. In the mandible the incisor process is comparatively narrow and terminates in four or five teeth. The palp is two-segmented, the basal segment being broadly expanded distally. The outermost of the three portions that compose the first maxilla is bifid at the extremity, each part bearing a single long seta.

The first and second maxillipedes (text-figs. 29*d*, *e*) are provided with large epipods; that of the former appendage is bilobed. The third maxillipedes reach beyond

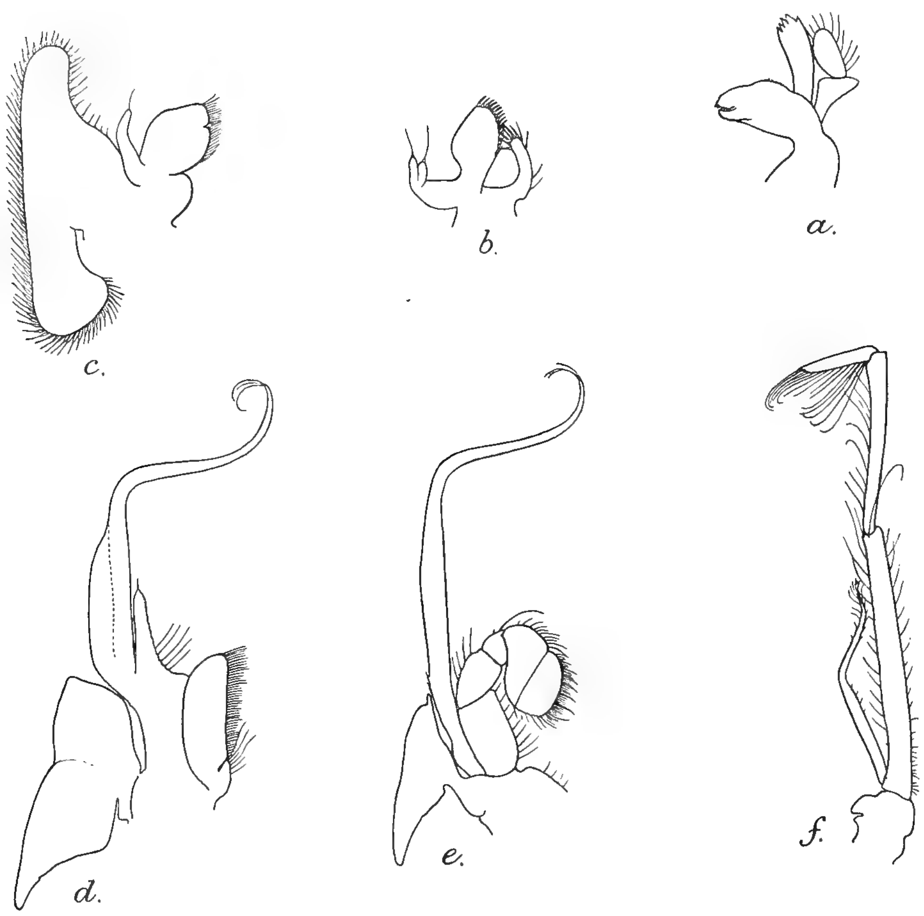

FIG. 29.—*Ogyrides striaticauda*, sp. nov.

a. Mandible.
b. First maxilla.
c. Second maxilla.
d. First maxillipede.
e. Second maxillipede.
f. Third maxillipede.

the end of the eyes by the length of the ultimate segment, which is invariably flexed upwards; the exopod reaches nearly to the end of the antepenultimate segment. The long plumose setae which clothe the limb are specially numerous on the ultimate segment, which is rather less than half the length of the penultimate. It will be noticed that the latter segment is much longer proportionately than in any other genus of the family.

The first peraeopods (text-fig. 30*a*) reach about to the end of the basal segment of the antennular peduncle. The ischium is swollen and, as in *O. sibogae*, is notched inferiorly at the base. The proportional lengths of the ischium, merus, carpus and chela are as 10, 18, 19 and 14½. The fingers are rather less than twice the length of

the palm; they gape slightly at the base when the claw is closed and their cutting margins are entire. Setae are thinly scattered on the lower edges of the ischium and merus[1] and on both margins of the carpus; on the chelae they are more numerous.

The second peraeopods (text-fig. 30*b*) reach a little beyond the tips of the eyes, the carpus, as in *O. occidentalis* and *O. sibogae*, being composed of four segments. The proportional lengths of ischium, merus, carpus and chela are as 13, 20, 22 and 10. Of the four segments which compose the carpus, the first is very long, nearly one and a third times the length of the three following combined; the second and fourth are nearly equal in length, almost twice as long as the third. The fingers

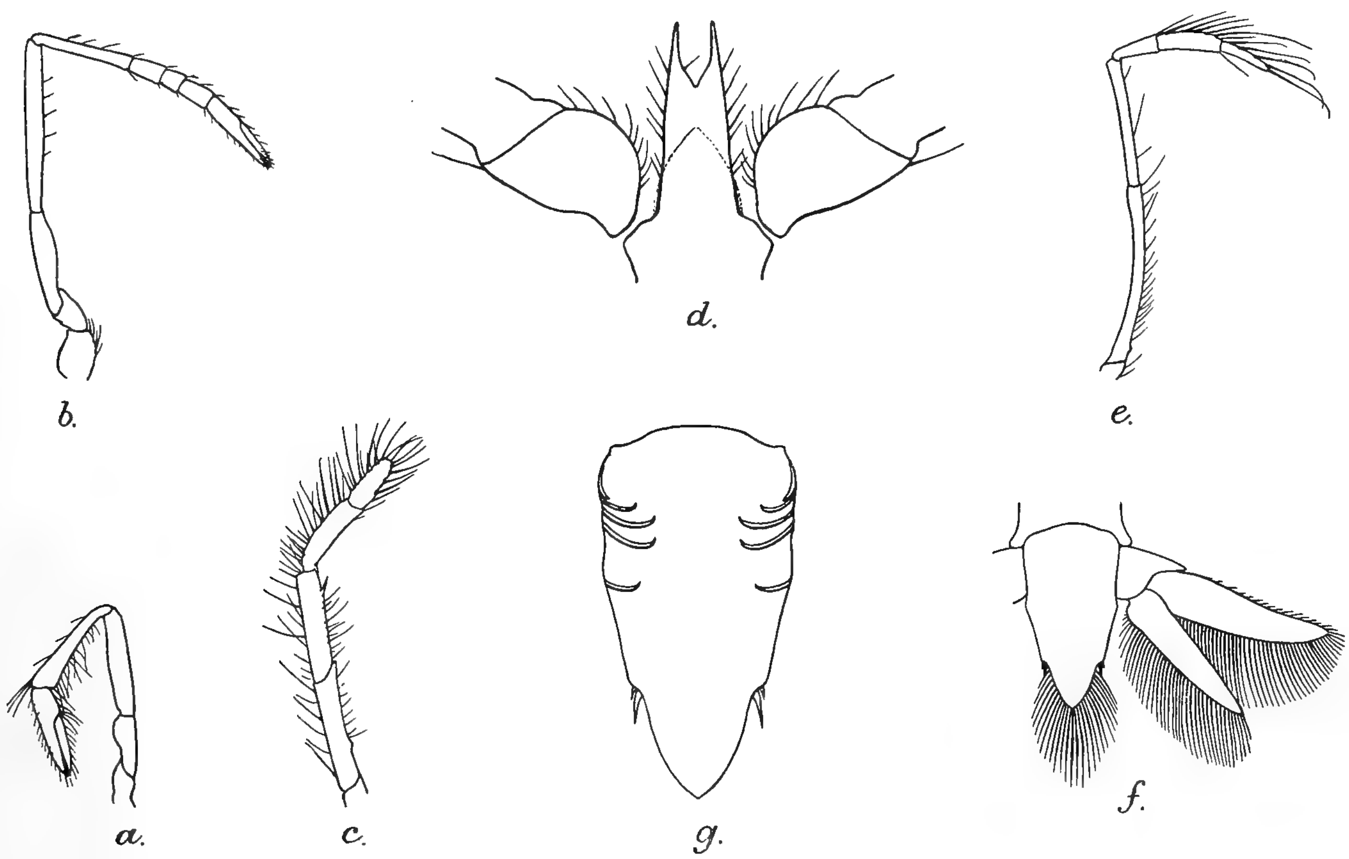

FIG. 30.—*Ogyrides striaticauda*, sp. nov.

a. First peraeopod.
b. Second peraeopod.
c. Third peraeopod.[2]
d. Sternal process at base of 4th peraeopods.
e. Fifth peraeopod.
f. Telson and right uropods from above.
g. Telson from below.

are a little more than one and a half times the length of the palm. The limb bears setae on the distal part of the carpus and on the chela.

Of the last three pairs of peraeopods the fourth is the longest, reaching as far forwards as the first, the third (text-fig. 30*c*) is the stoutest and the fifth (text-fig. 30*e*) the most slender. In the third and fourth pairs the dactylus[2] is very small; the

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[1] These are not shown in text-fig. 30*a*.

[2] The dactylus of the third peraeopod is not well shown in text-fig. 30*c*; it is very much more slender than the propodus and about one-third its length, bearing two short setae apically. The figure conveys the erroneous impression that the dactylus is absent and that the propodus bears two long setae, which are crossed, at its apex.

merus of the third bears a stout spine near the distal end of its lower border. All the segments bear setae, most thickly on the carpi and propodi of the third and fourth pairs and on the last two segments of the fifth. The proportional lengths of the ischium, merus, carpus, propodus and dactylus in the third pair are as 16, 14, $9\frac{1}{2}$, 6 and 2: of the same segments in the fourth pair as 16, 23, 11, 10 and 2: of the same segments in the fifth pair as $22\frac{1}{2}$, 15, $5\frac{1}{2}$, $7\frac{1}{2}$ and $5\frac{1}{2}$. Attached to the proximal segments of the fourth pair of legs is a curious elongated plate (text-fig. 30*d*) which extends forwards to the base of the third pair, lying close to the sternum. The lateral margins of this plate are straight, a little convergent distally, and its apex is deeply bifurcated.

The abdominal somites are smooth above; their pleura are rounded inferiorly. The length of the sixth somite is about equal to that of the fifth.

The telson is a little longer than the sixth somite and is shorter than both inner and outer uropods; it is slightly sulcate above and bears two pairs of small dorsal spinules (not shown in text-fig. 30*f*). At the distal end of each lateral margin are two pairs of spines and the apical portion between them is produced and at the extremity rather sharply angled. The innermost pair of spines, which is much the longest of the two, reaches to less than half the length of the produced median part. The breadth at the level of the spines is a little more than one-third the total length. The telson does not possess a feeble lateral prominence but on either side, situated in the proximal third and on the ventral surface, are four oblique ridges, the three anterior ones placed close together, the other rather more distant. The arrangement of these ridges, which appear to be characteristic of the species, is shown in text-fig. 30*g*. In spirit specimens they have a nacreous lustre and perhaps represent a stridulating organ, but I am unable to find that they possess transverse striae and there does not appear to be any ridge on the basal segment of the uropods which could be brought to bear upon them.

The outer uropod (text-fig. 30*f*) is longer than the inner; it is distally pointed, setose on both margins and about three and a half times as long as broad.

The largest specimen, an ovigerous female, is about 14 mm. in length.

A synoptic key and references to the four hitherto known species of the genus is supplied by de Man.[1] *O. striaticauda* is evidently a very close ally of *O. occidentalis*, Ortmann[2], from the mouth of the Tocantins River in Brazil. Ortmann's description is very brief and neither in it nor in the figures is there any indication of the ridges found on the telson in the Indian species; it is probable, therefore, that a well-marked difference exists in this respect between the two forms. In *O. occidentalis*, also, the eyes do not extend beyond the antennular peduncle and, according to the figures[3], the antennal scale is considerably longer than in *O. striaticauda*, the basal

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[1] De Man, *Decap. 'Siboga' Exped.*, II, *Alpheidae*, p. 135 (1911).

[2] Ortmann, *Decap. Schizop. Plankton-Exped.*, p. 46, pl. iii, figs. 4, 4*a-z*. (1893).

[3] The figures are perhaps not very reliable. That of the third leg at least is almost certainly erro-

segment of the mandibular palp is not widened distally, the exopod of the outer maxillipedes is much shorter, the three distal subsegments of the carpus of the second legs are of equal length and the telson is narrower, with the apex evenly rounded.

Living specimens of *O. striaticauda* were for the most part transparent, the greenish visceral and hepatic masses being clearly visible through the walls of the carapace. The eyestalks, antennules and antennae were pale red and the oral appendages, maxillipedes and first two pairs of legs bright red. On the first abdominal somite there were two transverse rows of red pigment spots and one similar row on each of the succeeding somites. The pleural margins were also red and the eggs borne by the ovigerous female were bright green.

O. striaticauda is apparently very scarce in the Chilka Lake: in all, only eight specimens were obtained. They were found in the outer channel in March, when the water was as salt as that of the sea outside the lake area, and in September, when it was entirely fresh. Three individuals were caught on the clean sandy bottom between Manikpatna and the mouth of the lake in company with *Pontophilus hendersoni*, while the remainder were obtained on the muddy ground in the vicinity of Barhampur I. No specimens were met with in the main area of the lake. The ovigerous female was found in March in salt water.

In addition to the Chilka lake specimens, there are in the Indian Museum numerous other examples obtained by Mr. F. H. Gravely in September 1914, in the Cochin backwaters near Ernakulam. There are ovigerous females among these specimens, though none were found at the same time of the year in the Chilka Lake. A few specimens were also taken in the Ennur backwater in January 1915, by Dr. Annandale. They were living on a bottom of almost pure sand in water of very low specific gravity. One female bore eggs.

Genus ATHANAS, Leach.

1899. *Athanas*, Coutière, *Ann. Sci. nat., Zool.* (8), IX, p. 323.

Among the species of this genus most marked differences exist in the degree of development of the first pair of legs. In most forms those of the male are greatly enlarged, much as in the genus *Alpheus*, and may be symmetrical or asymmetrical. In females the first legs may resemble those of the male, or one or both limbs may be small and slender.

In the species of *Athanas* found in the Chilka Lake the first pair of legs presents features of unusual interest and it seems desirable therefore, in the first place, to summarise our knowledge of the development of these limbs in the various forms that have been described.[1]

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neous, for Ortmann has apparently failed to discern the true division between the merus and ischium and has represented what is really the produced lower distal angle of the latter as a spine at the base of the former.

[1] A most valuable key to the species of *Athanas* has been supplied by de Man, *Decap. 'Siboga' Exped.*, II, *Alpheidae*, p. 146 (1911).

Species.	First pair of peraeopods.	
	Male.	Female.
Group of *A. nitescens.*		
A. nitescens, Leach ..	Asymmetrical, both enlarged ..	Asymmetrical, one only a little enlarged.
A. naifaroensis, Coutière..	Unknown..	Symmetrical, not greatly enlarged.
A. aretiformis, Coutière ..	One enlarged, the other unknown	One not greatly enlarged, the other unknown.
A. grimaldi, Coutière ..	Symmetrical, enlarged ..	Symmetrical, enlarged.
A. granti, Coutière ..	Asymmetrical, both enlarged ? ..	Asymmetrical, both enlarged ?
A. parvus, de Man ..	Unknown..	Symmetrical, not enlarged.
Group of *A. dimorphus.*		
A. dimorphus, Ortmann..	Symmetrical, enlarged ..	Symmetrical, not enlarged.
A. minikoensis, Coutière..	Asymmetrical, both enlarged .	Asymmetrical, one only enlarged.
A. haswelli, Coutière ..	Unknown..	One (? both) not enlarged.
A. orientalis, Pearson ..	Unknown..	Asymmetrical, one only enlarged.
A. djiboutensis, Coutière..	Asymmetrical, both enlarged ..	Asymmetrical, one only enlarged.
A. sibogae, de Man ..	Asymmetrical, both enlarged ..	Asymmetrical, both enlarged.
A. jedanensis, de Man ..	One enlarged, the other unknown	Symmetrical, not enlarged.
A. tenuipes, de Man ..	Unknown..	Unknown.

The single species of *Athanas* found in the Chilka Lake belongs, apparently, to a form hitherto unknown, but is closely allied to Ortmann's *A. dimorphus*. It was unfor-

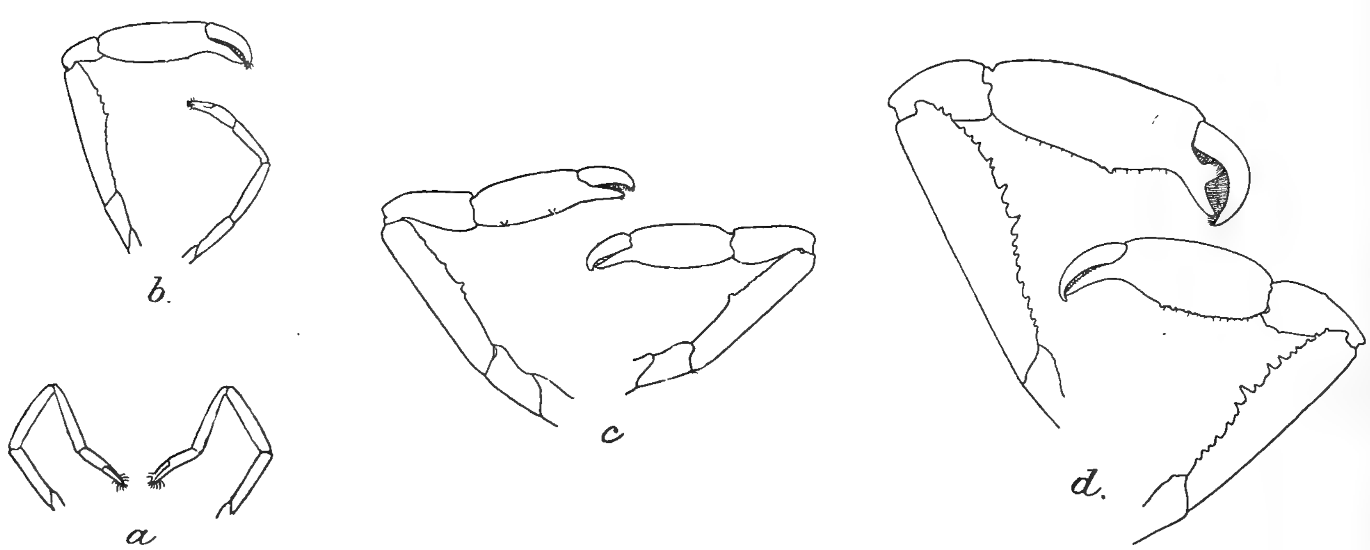

FIG. 31.—*Athanas polymorphus*, sp. nov.

a. First peraeopods of female. *c.* First peraeopods of male, form II.
b. *do.* of male, form I. *d.* *do.* of male, form III.

tunately very scarce, and of the twenty-seven specimens obtained only nine are males. These nine males, however, present a most notable diversity of form, a fact which has led me to assign to the species the name *Athanas polymorphus*.

As in *A. dimorphus* the first legs in the female are both slender (text-fig. 31*a*), with the carpus longer than the chela and are wholly dissimilar in structure from the large limbs of the male. But, apart from this feature, which evidently influenced Ortmann in his choice of a specific name, the males in the new species can be separated into three clearly defined groups according to the degree of development which

the first legs have attained. In the smallest males (five specimens) one of the first legs, either right or left, is identical in structure with that of the female, while the other is greatly enlarged, the fingers of the chela being curved and not provided with teeth (text-fig. 31*b*). In other males (two specimens) both legs of the first pair are equally enlarged, each being closely similar to the large limb borne by the preceding form (text-fig. 31*c*). In others again (two specimens) both legs are enlarged, but asymmetrical; one limb, except for the greater number of spines on the merus, is similar to that in the preceding group, while the other is a little larger and, apart from more trifling differences in forms, is provided with a huge rounded tooth on the fixed finger (text-fig. 31*d*).

The characters of the nine males may be tabulated thus :—

Date of capture.	Length of carapace.[1]	First peraeopods.
1914.	mm.	Form I, text-fig. 31*b*.
Sept. 9th	2·6 2·5	Asymmetrical. One, either right or left, enlarged, without tooth on fixed finger and with few spines on merus. Other slender, of proportions similar to those of female.
Sept. 10th	3·2 2·8	
Sept. 12th	2·3	
		Form II, text-fig. 31*c*.
March 22nd	5·0 4·3	Symmetrical. Both enlarged, without tooth on fixed finger and with few spines on merus.
		Form III, text-fig. 31*d*.
March 16th	4·4 4·1	Asymmetrical. Both enlarged, with numerous spines on merus. Right leg in both specimens with large rounded tooth on fixed finger. Left, in one specimen without tooth on finger (*i.e.* similar except for spines on merus to Form II), in the other specimen missing.

In all these specimens the appendix masculina on the second pleopods is well developed; there is thus no doubt regarding their sex. Also, it is in my opinion impossible that the small limb found in Form I is the result of regeneration. In almost all cases it is easy to distinguish a limb that has been broken off and subsequently grown again and it is, I think, inconceivable that in each of the five individuals of this form it should be equally and perfectly re-developed.

The case therefore is one of trimorphism, at any rate in a somewhat loose application of that term; but the specimens are so few in number that I have found it

[1] The measurement is taken from the posterior mid-dorsal edge of the carapace to the tip of the eye.

impossible to do more than make a few suggestions, some perhaps rather more probable than others, to account for the existence of this curious phenomenon.

It will be seen from the table given above that the largest and most fully developed specimens, Forms II and III, were caught in March, while all belonging to Form I are smaller and were obtained in September. The breeding season is apparently in March, for it was only in this month that ovigerous females were found. Judging by its size, Form I is probably the youngest and may represent a non-breeding phase; but it would be very extraordinary if the three forms were merely stages in the life-history of the species. In very young males, perhaps early post-larval forms, it is probable the first limbs are both slender, resembling those of the female and, if Forms I, II and III represent successive stages in growth, the development is, as far as I am aware, without parallel. On this theory the young male would, in the course of a few months, develop one enlarged limb, the pair being greatly asymmetrical (Form I). Later, at a subsequent moult, the other limb would be similarly enlarged, the pair thus becoming symmetrical (Form II), while still later asymmetry would again be manifest in the form of the chelae, the spines on the merus being increased in number in both limbs. According to this theory the males could not strictly speaking be regarded as trimorphic, the case would merely be one of a most unusual post-larval metamorphosis.

Another and perhaps rather more plausible suggestion may be made. The males may be strictly dimorphic, Forms II and III each representing the ultimate development in the life of an individual, each being a fixed type which never alters in the course of subsequent moults. On this theory Forms II and III would be developed simultaneously at the beginning of the breeding season from the non-breeding phase represented by Form I.

One more theory remains. The males may be strictly trimorphic, each of the three forms representing a fixed and unalterable type, predetermined perhaps from an early age. The facts available regarding the size and date of capture of the specimens seem to indicate that this view has but little to recommend it.

The three suggestions which have been made must, I think, exhaust all probable explanations of the case, for it is impossible that the three forms merely represent items in a series exhibiting normal variation. My suggestions may be summarised thus :—

Theory I. That the three forms of male represent merely so many stages in the life-history of this sex of the species.

Theory II. That the males are truly dimorphic, Forms II and III representing unalterable types developed simultaneously at the breeding season from the non-breeding Form I.

Theory III. That the males are truly trimorphic, each of the forms representing a type unalterable in the life of the individual.

At first glance it seems possible to find an analogy between the three forms of male in *Athanas polymorphus* and the three forms of the same sex known in certain

Oxyrhynch crabs; but it does not seem probable that the two cases are really identical, though in both it is the development of the first legs that is concerned.

According to Geoffrey Smith's investigations [1] three types of males are to be found in some species of Oxyrhyncha and he names these three types "low," "middle" and "high." In both low and high males the chelae are swollen, there being a marked difference between the two groups in the comparative size of the limbs. The chelipedes of the middle form are, on the contrary, scarcely swollen at all, resembling those of the females. The low males are smaller than the high and the middle intermediate in size. During the breeding seasons the majority of the males that are found belong to the low or high forms, while in the intervening seasons middle males predominate. The low male in the course of its development to the high form passes through a middle stage in which the sexual function is in abeyance.

The investigations made by Hagen [2] and Faxon [3] on American crayfish referred to *Cambarus* have brought to light the fact that in this genus there are two forms of male, distinguished by the shape of the first abdominal appendages, and it has been shown that these two forms represent breeding and non-breeding phases. An almost precisely similar phenomenon has been noticed by Wollebaek [4] in one of the Pandalidae, *Pandalus montagui* (= *annulicornis*), though it apparently does not occur in allied species of the genus.

It is evident that these two last instances, although the organs concerned are more directly connected with the sexual function, belong to the same category as that of the Oxyrhynch crabs, in which the peculiarities are shown in the chelipedes. Although phenomena of the kind seem to be rare in the Decapods, it is clear that instances of a seasonal sexual dimorphism occur in at least three widely separated groups of the order, *viz.* the Caridea, Nephropsidea and Oxyrhyncha.

True dimorphism, *i.e.* the "definitive dimorphism" of Smith, is well known in many insects; but, if it ever exists, is of extremely rare occurrence among Decapoda.[5] Henderson and Matthai [6] have, indeed, brought forward facts which seem to indicate that the Palaemonidae known as *Palaemon scabriculus*, *P. dolichodactylus* and *P. dubius* are in reality true trimorphic forms of a single species, differing from one another in the proportionate measurements of the large claws of the male. Further evidence is, however, necessary before this view can be accepted as definitely proved.[7]

It appears to be impossible to bring the case of *Athanas polymorphus* into line with any of these instances. That the males show a definitive trimorphism is, I

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[1] Smith, *Mitth. zool. Stat. Neapel*, XVII, p. 312 (1905).

[2] Hagen, *Ill. Cat. Mus. Comp. Zool.* II, pp. 20, 21 (1870).

[3] Faxon, *Mem. Mus. Comp. Zool.*, X, 4, p. 12 (1885).

[4] Wollebaek, *Bergens Museums Aarbog*, 1912, No. 8, p. 64.

[5] See my paper in *Rec. Ind. Mus.*, X, pp. 84-87 (1914) for a criticism of the supposed dimorphism in certain Hippolytidae and Palaemonidae.

[6] Henderson and Matthai, *Rec. Ind. Mus.*, V, p. 280 (1910).

[7] A definitive dimorphism is of course well known in Crustacea other than Decapods.

believe, most improbable, for the specimens of Form I were not obtained during the breeding season and in the non-breeding season occurred apparently to the exclusion of Forms II and III. It is clear, too, that the instance is not merely one of a seasonal sexual dimorphism such as occurs in *Cambarus* and *Pandalus*, though this may in part account for the peculiarities which have been noted.

On the evidence which I am able to offer, a parallel with the Oxyrhynch crabs also cannot be maintained, for Form I, which approximates most nearly to the female and might therefore be regarded as the representative of Smith's "middle" crabs, is not intermediate in size between Forms II and III, nor do these last forms show the marked difference in dimensions that one would expect if they corresponded respectively to the "low" and "high" forms in the Oxyrhynchs. Similarly it is impossible to regard the specimens of Form II as "middle" individuals: the measurements do not tally and the examples were found during the breeding season, at which time Form I was apparently absent.

The widespread though rare occurrence of a seasonal sexual dimorphism in the Decapoda suggests that this phenomenon will afford a partial explanation of the three forms of male in the Chilka species of *Athanas*. Form I, even though the appendix masculina is to all appearances fully developed, is probably a non-breeding phase of the sex. It is likely, on the other hand, that Forms II and III are breeding phases and, from the scanty evidence available, it seems reasonable to regard them as definitive dimorphic forms. This theory, the second of those listed on p. 292, appears to me the most plausible of any.

With further material it will be possible to determine if it is correct, and we may also be able to discover if Form I comprises specimens which have never bred or is a phase of a form that was once sexually active. From the specimens available it seems on the whole most probable that the former explanation is the true one and that males of Forms II and III perish at the close of the breeding season.[1]

The knowledge of the existence of three distinct forms of male in *Athanas polymorphus* must, I believe, have a marked effect on our views as to the systematic treatment of the genus, for it is not unlikely that different forms of the same species have been described under separate names.

I am inclined to think, also, that sufficient care has not been taken in determining the sex of the specimens described. When two forms of a species are found, that with the most highly developed limbs is considered to be the male and the other the female. Even Dr. de Man in his account of *Athanas sibogae* describes a specimen which "is considered to be the female of this species, with some doubt, because it carries no eggs"; it is not improbable that this example is really a second form of the

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[1] Eventually it may perhaps be possible to find some analogy between the phenomena found in *Athanas* and those discovered by Sewell in Copepoda. Sewell, in tracing the development of certain species of this group by the application of "Brooks' Law", has found that in the male there may be two definitive dimorphic forms, both mature. Individuals of stage IV of Sewell's terminology may develop directly into the "low" form or, with the intervention of an additional immature stage, may reach the "high" form. See Sewell, *Rec. Ind Mus.*, VII, p. 316 *et seq.* (1912).

male. In the determination of the sex it is essential that the second pleopods should be examined to ascertain whether the appendix masculina is present or absent.

There is one other point of more than systematic interest in the specimens of *Athanas* found in the Chilka Lake, and this concerns the development of the second pair of legs. The carpus of these limbs in *Athanas* is composed of five sub-segments, whereas in the allied genus *Arete* there are only four. In twenty-three specimens of *Athanas polymorphus* the carpus is on both sides composed of five sub-segments and has a similar development in the single limb of the pair which alone persists in two additional specimens. The two remaining examples are, however, abnormal. In one of them, a male belonging to Form I, the carpus on one side is five-, and on the other four-segmented, while in the other specimen, which is a female, both the carpi are composed of only four segments (text-fig. 32*e*). The last specimen, if it had been taken alone, would almost certainly have been described as a new species of *Arete*, bearing a close resemblance to *Athanas*.

It is, however, through the *nitescens* group of *Athanas* that Coutière would derive *Arete* and not through the *dimorphus* group to which the Chilka species belongs.

Athanas polymorphus, sp. nov.

The rostrum is without teeth and reaches almost to, or a little beyond the end of the second segment of the antennular peduncle. In two large males (those belonging to Form III) it has evidently suffered injury and is abruptly curtailed at the apex, reaching only to the middle or end of the basal antennular segment. The dorsal carina of the rostrum extends backwards and is visible in the anterior sixth of the carapace. The supra-corneal spine is entirely absent; the extra-corneal is well developed, reaching to about half the length of the eye. The infra-orbital angle ("dent infra-cornéene" of Coutière) is small, but acute, though less spinous in character than the extra-corneal. There is also a sharp tooth opposite the insertion of the antennae, absent in *A. dimorphus*, which must, I think, be the homologue of the pterygostomian spine (text-figs. 32*a*, *b*).

The eyes are small, but well pigmented. The antennular peduncle reaches to the apex of the rostrum. The basal segment is little longer than the second and on its infero-internal margin bears, as is usual, a well-marked longitudinal crest, which terminates anteriorly in a tooth reaching almost to the distal end of the segment. The lateral process (stylocerite) is composed of a long spine which extends only a little beyond the end of the segment. The second segment is about one and three quarter times as long as the third. The inner antennular ramus is longer than the outer: the latter is distally bifid and the thicker of its branches, which is much the shorter, is about as long as the peduncle. The fused part is composed of from 8 to 10 segments and the free portion of the outer and thicker of the two branches is from one half to three quarters its length.

The carpocerite reaches almost to the end of antennular peduncle. The anten-

nal scale (text-fig. 32*c*) is from 2·4 to 2·5 times as long as wide and the straight outer margin terminates in a sharp spine which reaches to, or a trifle beyond, the broad apex of the lamella.

The outer maxillipedes reach to the end of the second segment of the antennular peduncle and possess an epipod "en crochet." The terminal segment is stouter than the penultimate and is about one and three quarter times its length.

The first peraeopods of the female are both slender, as in *A. dimorphus*, and, if extended, would reach about to the end of the antennal scale; in both sexes they are, however, habitually flexed at the carpo-meral joint. In the female the legs of this pair are equal, or very nearly so, the carpus and ischium are almost equal in length, the merus sometimes just a trifle longer. The chela is about three-quarters the length of the carpus and the fingers are as long as the palm. The segments are

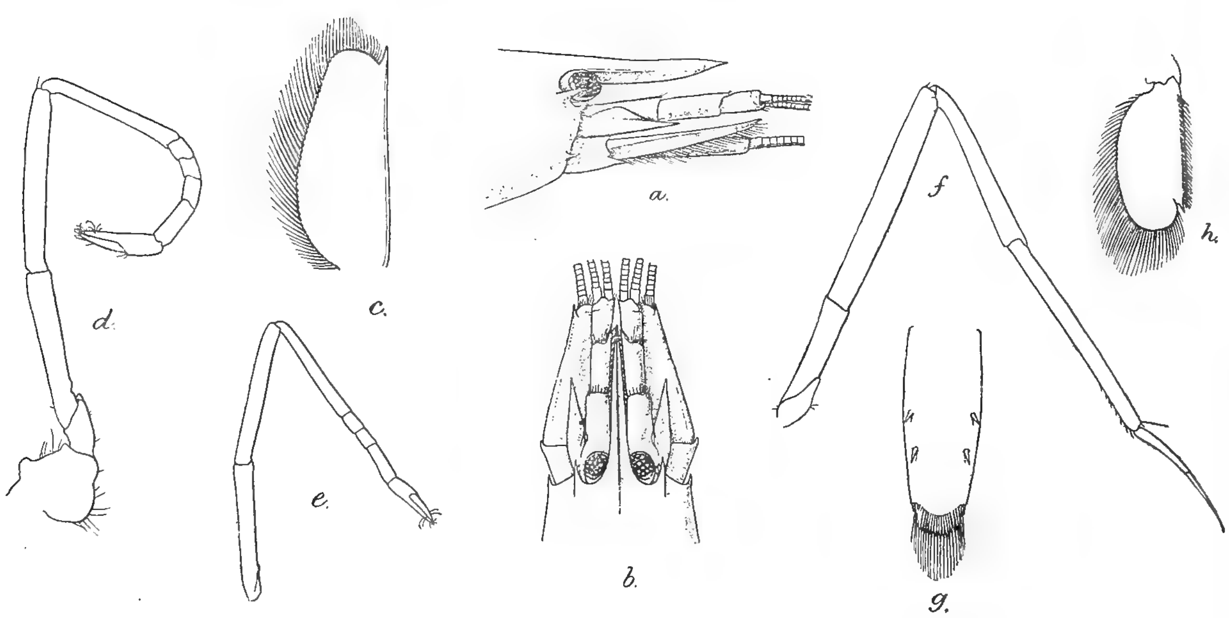

FIG. 32.—*Athanas polymorphus*, sp. nov.

a. Anterior part of carapace, rostrum, etc., in lateral view.
b. *do.* in dorsal view.
c. Antennal scale.
d. Second peraeopod.
e. Second peraeopod with abnormal segmentation.
f. Fifth peraeopod.
g. Telson.
h. Outer uropod.

devoid of spines and, except for a few hairs on the fingers, are glabrous (text-fig. 31*a*).

In males, as has already been explained (p. 291) the legs of the first pair are of three types. In Form I (text-fig. 31*b*) the limbs are very asymmetrical, one resembling that of the female, while the other is greatly enlarged. The slender limb differs, however, from that of the female in its proportional measurements, the merus being almost one-third longer than the carpus, while the chela is scarcely shorter than the latter segment. The large leg of Form I is very different in structure; the ischium is quite short and the merus large with its outer lower edge dilated, forming a sort of recess into which the chela fits when the limb is folded. The merus is about five times as long as broad and is only a trifle shorter (as 18 to 19) than the

greatly enlarged chela; on its inner edge is a series of small teeth, varying in size, but for the most part ill-developed. The carpus is very short, about two-sevenths the length of the merus, and its breadth is about half its length. The chela is about four times as long as broad; the palm is 2·7 times as long as broad and about twice the length of the dactylus. In front of its middle point, on the antero-internal aspect, there are usually one or two small tubercles. The fingers are without teeth on their cutting edges; the dactylus is strongly curved and longer than the fixed finger, which is nearly straight and bluntly pointed apically.

In males of Form II (text-fig. 31*c*) the first peraeopods are symmetrical, or nearly so, each being similar to the large limb of Form I. The merus in the specimens of this form is a little longer than the chela and is less expanded than in Form I, being 5·4 times as long as broad. The carpus is longer, fully half the length of the merus, while the chela has much the same proportions, but is a little broader, about three and one third times as long as wide. A tubercle is sometimes seen on the antero-internal aspect of the palm and there are a few spines on the inferior margin of the merus.

In Form III (text-fig. 31*d*) the legs of the first pair are asymmetrical, though both are much enlarged. In both limbs the spines on the border of the merus are more numerous and better developed than in Forms I and II and there may also be small tubercles on the carpus and a series on the inner face of the palm. The smaller limb bears a close resemblance to those found in Form II. The merus is 4·7 times as long as wide, the carpus is a little less than half its length and is about twice as long as broad. The chela is about three times as long as broad and the dactylus is more than half the length of the palm. In the larger limb the merus is similar, 4·6 times as long as wide, while the carpus is distinctly shorter, about one-third the length of the merus. The chela is a little shorter than the merus and about three times as long as broad. The fixed finger differs conspicuously from that borne by the leg on the other side of the animal in the possession of a large rounded tooth or lobe near the middle of its inner margin.

The second peraeopods (text-fig. 32*d*) are folded like those of the first pair, being flexed at the mero-carpal articulation. The merus is a little longer than the ischium; the carpus is almost one and a half times the length of the merus and is fully three times as long as the chela. The carpus in all except two individuals is composed of five sub-segments: the first is much the longest, almost three times the length of the fifth, and the second, third and fourth are subequal and but little longer than broad, each being about half the length of the fifth. The dactylus is a little longer than the palm. As noted above (p. 295) the carpus in one male belonging to Form I is, on one side only, composed of four sub-segments, while in one of the females each limb of this pair has a similar development. The reduction in number is apparently brought about, in these abnormal individuals, by the fusion of the two proximal segments (text-fig. 32*e*).

The last three pairs of peraeopods are similar; their segments are devoid of spines and their dactyli are simple, not biunguiculate as in certain other species of

the genus. The third pair, which is the longest, reaches beyond the apex of the antennal scale by the length of the dactylus; the fifth reach almost to the end of the second segment of the antennular peduncle. In the third pair the carpus is a little longer than the propodus, nearly one and a half times the length of the ischium, and about three quarters as long as the merus. The latter segment is eight times as long as broad. The dactylus is slender, slightly curved, and terminates in a very fine claw which is nearly as long as the segment proper. The propodus is about 1·7 times the entire length of the dactylus.

In the fifth peraeopods there is a series of setae, not found on the two preceding pairs of limbs, at the distal end of the propodus on its inferior surface. The carpus is one-fifth shorter than the propodus, the latter segment being about equal in length with the merus. The merus is eight times as long as wide and about twice the length of the ischium; the dactylus has the same proportion to the propodus as in the third leg (text-fig. 32*f*).

The branchial formula is apparently the same as in other species of the genus; epipods "en crochet" (epipod *a* of Coutière's terminology) are present on the first three peraeopods.[1]

The abdominal pleura are rounded, except for that of the fifth somite, which is acutely pointed behind, and for the posterior angle of the sixth, which is also acute and articulated as in other species of *Athanas*.

The appendix masculina is well developed in all the males and is about the same length as the appendix interna.

The telson (text-fig. 32*g*) is as long as the uropods. It is a little less than four times as long as the breadth between the posterior angles and bears two pairs of dorso-lateral spinules. The margin between the two pairs of postero-lateral spinules is gently rounded and fringed with long setae, each seta being markedly swollen at the base. The inner of the two pairs of spinules is more than twice as long as the outer, both extending beyond the apex of the median portion. The outer uropod (text-fig. 32*h*) bears a fringe of setae on the under side, running parallel with, and close to, the external margin; it is a little more than twice as long as broad.

A large male is only about 15 mm. in total length; the ovigerous females do not exceed 13 mm.

Athanas polymorphus is evidently closely allied to Ortmann's *A. dimorphus*[2] and would find a place next that species in the admirable key which de Man has provided (*loc. cit.*, p. 289, footnote). Both sexes of the Chilka Lake species are readily distinguished from *A. dimorphus* by the presence of a spine near the antero-lateral angle of the carapace, while males may be separated at a glance by the spines on the inferior edge of the merus in the enlarged first leg. From all other species in the same section of the genus it is distinguished by the great length of the carpus in the first legs of the female.

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[1] See Coutière, *Ann. Sci. nat., Zool.* (8), IX, pp. 276, 277 (1899).

[2] Ortmann, in *Semon's Zool. Forschungsreis. in Australien, etc.*, V, p. 12, pl. I, fig. 1 (1894).

The species is beautifully coloured in life. The entire animal is very closely dotted with large maroon chromatophores, the gastric and hepatic regions sometimes showing faintly through the carapace as reddish or greenish masses. The following conspicuous patches of cream or lemon yellow occur:—a transverse bar, sometimes merely a spot, situated dorsally in the middle of the carapace and another, always well marked, at the posterior end of the carapace, occupying three-quarters of its breadth in dorsal view; a large spot on either side of the first abdominal somite; a similar spot on the second somite, with another lower down near the pleural margin, and a large mid-dorsal patch or transverse streak; a transverse band on the third somite and a large pleural spot; a similar band on the fourth somite, rarely broken into three patches. The fifth somite is maroon, rarely with a pair of small cream-coloured spots posteriorly, and the posterior half of the sixth is entirely lemon yellow or cream. The tip of the telson is sometimes cream, sometimes undifferentiated. The antennules and antennal scales are often maroon, resembling the other parts of the animal, or, in paler individuals, faintly mottled or wholly transparent. All the maxillipedes and legs are transparent with a slight purplish tinge. The eggs are very dull sage green.

When walking *A. polymorphus* used only the last three pairs of legs, the first two pairs being folded beneath the carapace. The antennules were held straight forwards and the antennae at right angles.

The species is described from twenty-seven specimens, eighteen females and nine males. Of the latter five are of Form I, two of Form II and two of Form III. All were obtained in the outer channel off Satpara and Barhampur I. on a muddy bottom at depths ranging from 6 to 10 ft. Examples were caught both in March, when the water was as salt as that of the Bay of Bengal near the lake, and in September when it was quite fresh. In the latter month only males of Form I and non-ovigerous females were found, whereas in March the males obtained belonged either to Form II or to Form III and three of the females were bearing eggs.

Genus **ALPHEUS**, Fabricius.

Alpheus crassimanus, Heller.

1865. *Alpheus crassimanus*, Heller, *Crust. 'Novara'-Reise*, p. 107, pl. x, fig. 2.

1888. *Alpheus crassimanus*, Bate, *Rep. 'Challenger' Macrura*, p. 554, pl. xcix, fig. 2.

1898. *Alpheus lobidens*, Coutière, *Notes Leyden Mus.*, xix, p. 199.

1899. *Alpheus crassimanus*, Coutière, *Ann. Sci. nat., Zool.* (8), ix, p. 239, text-fig. 293.

1902. *Alpheus crassimanus*, de Man, *Abhandl. Senckenb. Ges. Frankfurt*, XXV, p. 880, pl. xxvii, fig. 62.

1911. *Alpheus crassimanus*, de Man, *Rep. 'Siboga' Decap.*, II, *Alpheidae*, p. 417.

The characters on which I have relied for the identification of this species are the following:—

The rostrum reaches to a point midway between the margins of the orbital hoods and the end of the first antennular segment. It extends backwards nearly to the

base of the hoods as a thin well-marked crest (not flattened above) and is rendered the more conspicuous by the comparatively deep depressions which exist on either side of it. The dorsal edge, which is, as a rule, a little concave, is concealed in lateral view by the rather elevated eye-hoods.

The dactylus of the smaller chela of the male is subspatulate in form, "Balaeniceps"-shaped; in the female the dactylus of this chela is slender. In both limbs and in both sexes there is a sharp spinule at the distal end of the infero-internal margin of the merus, while there is no tooth on either side of the insertion of the dactylus.

In the large chela the depressed area on the supero-internal face is triangular in shape and the lobes on the upper and lower margins of the palm are distally rounded (not acutely produced). The small chela of the male is scarcely, if at all, more than three and a half times as long as wide and the palm is distinctly notched, both dorsally and ventrally, behind the fingers.

The merus of the third legs is without teeth and is rather less than five times as long as wide. The dactylus of the last three pairs of legs is simple.

The specimens which possess these characters were found among clumps of oysters in the outer channel of the lake and agree very closely with de Man's detailed description (*op. cit.*, 1902). When the antennule is dissected out, the second peduncular segment proves in reality to be but little longer than the first, though, if the measurements be taken along the inner edge, the former is, as in de Man's account, about one and a half times the length of the latter. In the large chela the total length is from 2·1 to 2·3 times the greatest width, the claw being therefore rather broader than in the specimens examined by de Man in which the same proportion varies from about 2·3 to 2·45.

Other examples found under rocks at the south end of the main area of the lake differ rather notably from those obtained in the outer channel, but must, I believe, be referred to the same species. In all these specimens the rostrum is less sharply carinate than in the others and the grooves on either side of it are broader and shallower. The large chela also is narrower—a difference readily noticed without measurement—the length being from 2·4 to 2·48 times the greatest breadth. In other respects these individuals agree with those from the outer channel.

Dr. de Man, when examining the 'Siboga' material of this species, notes that two specimens from a single locality differ notably from the remainder in having stouter limbs, and it is probable that phases showing more or less distinct minor characteristics, presumably adaptational, are to be found in different regions. The occurrence of two such phases in the Chilka Lake is of no little interest, owing to the close proximity of the localities in which they were found and to the wide differences in environment.

The form obtained in the outer channel lives among clumps of oysters, practically always submerged; the water, during some nine months of the year, is as salt as that of the Bay of Bengal outside the lake (sp. gr. 1·0265), while for the other three it is almost entirely fresh. The form occurring at the south end of the main area is subjected to much less violent changes in salinity and lives under stones and

boulders, which under certain conditions of flood, tide and wind are above water-level. According to our observations the specific gravity of the water in this part of the lake varies from 1·006 to 1·015. Our collections show that the species occurs in both localities throughout the year.

Ovigerous females were found at the south end of the main area in March and, on the oyster beds in the outer channel, in September and December. The eggs are a little more than ·5 mm. in diameter. The largest individual is about 36 mm. in length.

An individual from Rambha Bay was, in life, of a dull greenish colour with darker green markings on the large chela; there was also a small black spot on each side of the second and fourth abdominal somites. In the large chela the tips of the fingers are pink.

This species does not construct an elaborate burrow, although when found under stones on soft mud it appeared to have excavated a short horizontal tunnel, probably never more than a few inches in length. The sound made by the species is very loud and we frequently heard it when walking near the places in which specimens were living.

Alpheus crassimanus is known to have a distribution extending from Djibouti to Celebes.

Alpheus malabaricus, Fabricius.

1798. *Alpheus malabaricus*, Fabricius, *Ent. Syst. Suppl.*, p. 405.
1893. *Alpheus malabaricus*, Henderson, *Trans. Linn. Soc., Zool.* (2), V, p. 434, pl. xl, figs. 1-3.
1911. *Alpheus malabaricus*, de Man, *Rep. 'Siboga' Decapoda*, II, *Alpheidae*, p. 330 (in key to species).

In his account of the 'Siboga' Alpheidae de Man recognises two varieties of this species, var. *dolichognathus*, Ortmann, and var. *leptopus*, de Man, and the characters by which these three forms are differentiated are shown in his key.

The specimens from the Chilka Lake unquestionably represent the typical form of the species and agree precisely with Henderson's description. It is also clear, from de Man's key, that they should be referred to this form; but the carpocerite[1] resembles that of *A. macrodactylus*, Ortmann, being equal in length with the antennular peduncle.

In the large chela of the specimens from the Chilka Lake the proportion of length to breadth is apparently variable; it is 3·6 times as long as broad in an adult female, 2·76 times in an adult male and 3·16 times in a younger male. In the third pair of legs the merus is nearly 7 times and the propodus about 10 times as long as broad.

On the whole the typical form seems to resemble the var. *leptopus* more nearly than the var. *dolichognathus*; but in the former variety, as shown in de Man's key,

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[1] By the term carpocerite I understand the fifth segment of the antennal peduncle (*see* Calman in *Lankester's Treatise on Zoology, Crust.*, p. 265, text-fig. 156B, 1909) and I am unable to understand de Man's reference (*op. cit.*, p. 430, para. 2) from which one would gather that the carpocerite is composed of three segments.

the fingers of the small chela gape[1] and in the detailed description it is stated that their inner margins are unarmed. In typical *malabaricus* the fingers are parallel and meet throughout their length when the claw is closed (there is a slight gape in one specimen) and at the base of the dactylus, as described by Henderson, there is a large tooth.

In young specimens the spine which terminates the outer margin of the antennal scale frequently reaches forwards beyond the apex of the lamella as in var. *dolichognathus*; in large individuals, as in var. *leptopus*, it does not exceed this point.

It may hereafter be found that the two varieties cannot be maintained, though, in the present state of our knowledge, the three forms may be distinguished by the parallel or gaping fingers of the small chela, by the presence or absence of a proximal tooth on inner margin of the dactylus and by the relative proportions of the segments of the last three pairs of legs.

The largest specimen in the collection has a length of 29 mm. In this example the length of the large chela is 17 mm.

The colour of living specimens is very striking. The entire animal is semi-transparent with chromatophores of bright red or reddish-brown pigment arranged in transverse bars on the carapace and abdomen. The gastric and hepatic organs show through the carapace as blackish and greenish masses. Each of the transverse bars of chromatophores is broadest in the middle, narrowed and directed forwards on either side. On the carapace are four such bars, the posterior much the broadest, while on the abdomen there are seven, the last extremely narrow. There are also red chromatophores at the base of the telson and in the centre of the uropods, while the tips of these segments and of the telson are heavily blotched with deep blue. The antennules and antennae are almost colourless. The chelae of the first legs are dull sage green, dotted with reddish-brown, the tips of the fingers in the larger claw being fawn-coloured or pink. The second legs are transparent, dotted with red distally, and the last three pairs are transparent with the mero-carpal and carpo-propodal joints bright yellow. The eggs borne by ovigerous females are dull yellow.

Alpheus malabaricus is not uncommon in the outer channel of the Chilka Lake, but has not been found in the main area. It was taken off Satpara and in the vicinity of Barhampur I. at depths varying from 6 to 12 ft. living on a bottom of soft mud. Its habits are thus strikingly different from those of *A. crassimanus*, which occurs only on rough ground,—on oyster-beds or under stones. The species was found both in March, when the water was as salt as that of the Bay of Bengal near the lake-mouth, and in September when it was quite fresh. The only ovigerous female in the collection was obtained in March.

Dr. Annandale found examples of this species, also on muddy ground, in the Ennur backwater near Madras in January 1915. The species occurred in water of specific gravity 1·002 and one individual was bearing eggs.

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[1] The reference to this point in the full description of var. *leptopus* is obscure, for the fingers are described as having "their inner margins shutting together."

The original specimens examined by Fabricius were from the "Indian Ocean"; Henderson's material was obtained at Pulicat, a locality not far distant from Ennur. Ortmann's var. *dolichognathus* is recorded from the Bay of Tokyo and de Man's var. *leptopus* from the East Indian Archipelago, S. of Celebes. One specimen of the var. *leptopus* was found at the unusual depth of 289 metres.

Alpheus paludicola, sp. nov.

(Plate XIII, figs. 11-13.)

A species belonging to the *edwardsi* group, allied to *A. euphrosyne*, de Man, and *A. microrhynchus*, de Man.

The rostrum is exceedingly small, less conspicuous even than in *A. microrhynchus*, and consists of a minute triangular plate which reaches but little beyond the level of the extremities of the orbital hoods. Behind it the inter-orbital region is flattened and the post-rostral keel is quite obsolete, existing merely as an extremely feeble elevation, which can only be seen in dried specimens and disappears altogether before reaching the middle of the inter-corneal area. There are no perceptible inter-orbital grooves on either side of the middle line. The orbital hoods are well in advance of the anterior margin of the carapace on either side; their frontal edges are not strongly convex (pl. xiii, fig. 11). The carapace, except for a few microscopic punctuations, is smooth.

The lateral process of the basal antennular segment is broadly oval and terminates in a small spine which does not reach the end of the segment. The second segment is about equal in length with the first and about two and a half times as long as broad; the third segment is much shorter. The thickened portion of the outer flagellum is a little longer than the peduncle.

There is no anterior spine on the lower margin of the basicerite of the antenna. The carpocerite is slender and reaches beyond the antennular peduncle by a distance nearly equal to that of the last segment of the latter. The antennal scale (text-fig. 33*a*) is not so broad as in *A. euphrosyne*; the length is about 2·4 times the width. The spine which terminates the slightly concave outer margin reaches very little, if at all, beyond the apex of the lamella.

The ultimate segment of the outer maxillipede is fully one and three quarters the length of the penultimate; both these segments are much more slender than the antepenultimate.

In the large chelipedes the merus in large males may be only twice as long as broad; in a younger male 2·4 times and in an adult female 2·7 times. The upper edge is rounded and the spine found in *A. edwardsi* and *A. crassimanus* at the distal end of the infero-internal margin is absent. The carpus is very short, rounded above.

The large chela (pl. xiii, figs. 12, 13) is from 2·4 to 2·5 times as long as broad, the palm being about 1·5 times as long as broad. The rounded upper edge of the palm terminates obtusely in front of a well-defined transverse groove situated near the base of the dactylus; the lower edge ends more abruptly in a rounded prominence

at the base of the immobile finger. Near the upper edge of the palm, as in *A. crassimanus* and allied species, are two depressions, one on the inner surface and one on the outer: that on the inner surface is triangular in shape and that on the outer more or less quadrangular. These depressions are united by the transverse groove at the base of the dactylus. The inner surface of the palm, as in *A. crassimanus*, bears in its lower half a sharp transverse ridge near the base of the immobile finger; this ridge runs towards the prominence terminating the lower margin, but is separated from it by a longitudinal, infero-internal groove which extends backwards for almost the entire length of the palm. There is also another ridge, transverse in direction, which crosses the middle of the inner surface of the palm; it is bounded proximally by a curved groove which runs to the carpal articulation and between it and the more anterior transverse groove at the base of the immobile finger is a large shallow depression. These ridges and grooves on the inner surface of the palm appear to be characteristic of the species. Characteristic also is a very fine granulation on the inner side of the immobile and fixed fingers; the surface of the former is evenly rounded, but bears a short though conspicuous carina near the finger-tip. The outer surface of the chela more nearly resembles that of *A. crassimanus*; there is a broad shallow groove on the fixed finger and a feeble depression proximal to the transverse ridge which terminates on the marginal prominence at the end of the lower edge of the palm. In external view the inner margin of the fixed finger is prominently angled just in advance of the socket for the great tooth of the dactylus; near the apex the inner margin of the movable finger is decidedly sinuous. The fingers open somewhat obliquely, that is to say, in a plane different from that of the outer surface of the palm. The large chela of the female is proportionately a trifle broader than in the male, but has a closely similar structure.

As in most species of the *edwardsi* group the dactylus of the small chela is, in the male, subspatulate in form, "Balaeniceps-shaped," whereas in the female it is slender. In the male (text-fig. 33*b*) the small chela is nearly five times as long as broad and the fingers are about equal in length with the palm. On the upper edge of the latter there is a transverse groove behind the insertion of the dactylus and in lateral view the margin is consequently notched; there is a similar notch, rather less conspicuous, on the lower edge near the base of the fixed finger. On either side of the upper edge is a triangular depression reaching backwards to the middle of the palm and on the infero-internal aspect another longitudinal groove which extends almost the whole length. The palm is quite smooth, without the granulations found in *A. euphrosyne*. The greatest breadth of the dactylus is about one-third its total length. On its upper surface at the proximal end are two low crests, short, distally convergent and bearing a few setae. A sharp keel runs the whole length of the inner margin. Both fingers are strongly curved at the tips.

The small chela of the female is rather less than five times as long as broad and the fingers are a little longer than the palm. In both sexes the chela bears scattered setae, more numerous in the female than in the male.

In the second peraeopods (text-fig. 33*c*) the ischium is a little longer than the

merus, the latter segment being six and a half times as long as wide. The carpus is nearly one and a half times as long as the merus. Of the five segments of which it is composed, the first is about twice as long as the second; the fifth is nearly three quarters the length of the second and is nearly as long as the third and fourth combined, the two latter being sub-equal. The chela is a little longer than the second carpal segment; the palm is less than one and a half times as long as broad and is two-thirds the length of the fingers.

The merus of the third peraeopods is unarmed and is a little more than five times as long as broad. The propodus is slightly tapering, nine times as long as broad at the base; it bears long setae but no spines and is two and three quarter

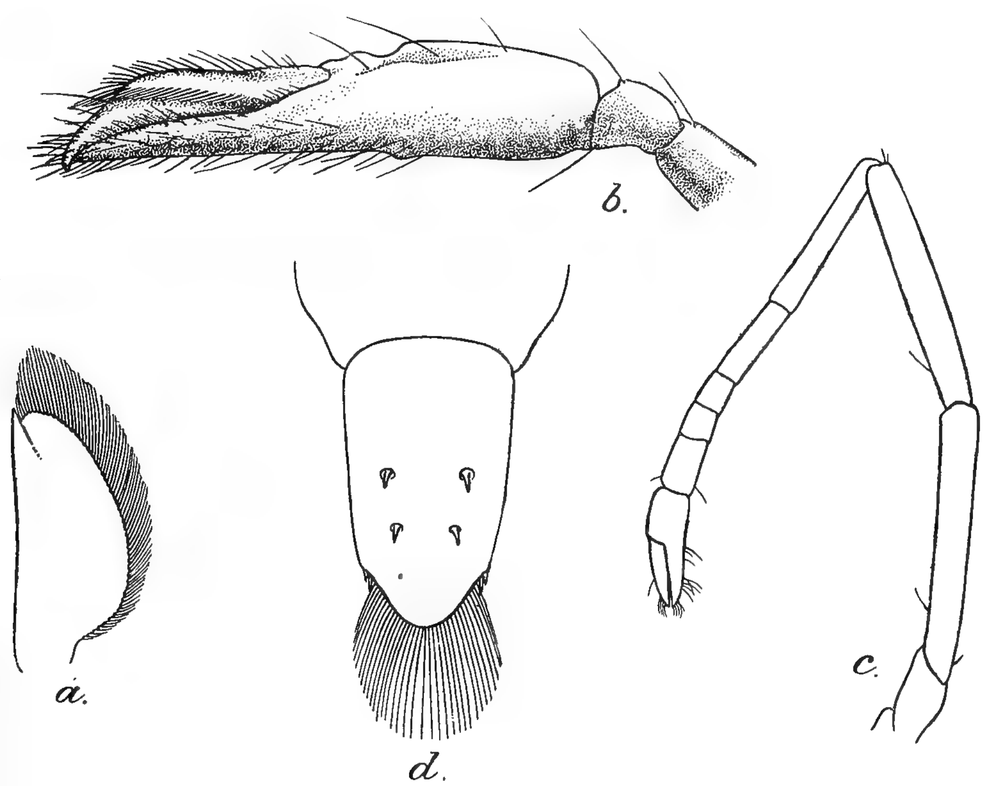

FIG. 33.—*Alpheus paludicola*, sp. nov.

a. Antennal scale. *c.* Second peraeopod.
b. Small chela of male. *d.* Telson.

times as long as the dactylus. The latter segment is spatulate as in *A. crassimanus* and is externally ridged. The remaining two pairs of legs are similar in form.

The telson (text-fig. 33*d*) reaches about as far as the uropods. The setose apex is rounded, but is produced far beyond the lateral spines. The breadth at the level of these spines is almost or quite two-thirds the basal breadth and is from one half to two-fifths the total length. The usual two pairs of dorso-lateral spinules are present, the proximal pair situated about in the middle of the telson. Both uropods are very broad; the exopod is nearly circular, little more than one and a quarter times as long as broad.

Large specimens of this species reach a length of about 22 mm. The eggs borne by females are very large, about 1·4 mm. in diameter.

Alpheus paludicola is allied to *A. euphrosyne*[1], de Man, and *A. microrhynchus*, de Man, and would find a place alongside these forms in the key which is supplied in the Report on the 'Siboga' Alpheidae. It agrees with these species and differs from *A. edwardsi*, Aud., *A. crassimanus*, Heller, and other closely related forms in the absence of a spine at the distal end of the infero-internal margin of the merus of the first peraeöpods. It resembles *A. euphrosyne* in having both margins of the palm of the small chelipede of the male notched and *A. microrhynchus* in the diminutive size of the rostrum and large size of the eggs.

From *A. euphrosyne* the Chilka species may be distinguished by the much smaller rostrum, the narrower antennal scale, the more slender form of the small chela of the male (in *A. euphrosyne* it is only four times as long as broad), the different proportions of the segments in the carpus of the second peraeopods and the larger eggs. The large chela of *A. euphrosyne* has not been figured, but is apparently somewhat similar to that of *A. paludicola*. De Man describes granulations at the base of the fixed finger similar to those found in the Chilka species; but he also notes the existence of granulations on certain parts of the outer surface, and of these in *A. paludicola* there is no trace. In *A. euphrosyne*, moreover, the large chela is more slender, about three times as long as broad.

In *A. microrhynchus* the rostrum, though small, is decidedly larger than in the species from the Chilka Lake, there are no granulations on the large chela, the upper and lower margins of the small chela of the male are not notched behind the fingers and the proportional lengths of the carpal segments in the second legs are different.

Specimens were semitransparent in life, the black gastric mass and the intestinal canal being clearly visible through the carapace. The rostrum was brownish-red and the antennular peduncles and outer margins of the antennal scales were tinged with the same colour. At the hinder end of the carapace and of each of the abdominal somites was a transverse band of brown pigment, sometimes tending to a bluish-green shade laterally. The telson and uropods were as a rule dusky, often with a faint speckling of red and not infrequently suffused with light blue. The inner surface of the larger chela was reticulated proximally with dull brown. The base of the fingers and the ridges on the palm were greenish or greenish-blue, the tips of the fingers pink. The outer surface was pale. The small claw was feebly pigmented and the other legs entirely transparent.

Two individuals lived for about three months in a shallow dish, fresh water being added occasionally to compensate for evaporation. They constructed only the most rudimentary burrows, using the last three pairs of legs in excavation and their pleopods in wafting away the mud. Whenever possible the burrows were dug underneath shells or pieces of weed; they were entirely horizontal and never much longer than the animal. The large chela was used as a lever in removing obstructions.

Alpheus paludicola is common in the Chilka Lake; specimens were found at no less than twenty-one different stations. It was found over an area extending from

[1] For references to these species see de Man, *Decap. 'Siboga' Exped.*, II, *Alpheidae*, p. 413.

Rambha to Nalbano and also occurred off Barnikuda, in Seruanaddi, near Satpara and in the vicinity of Barhampur I. It was invariably obtained on a bottom of soft mud in water from 4 to 12 ft. in depth. Unlike *A. crassimanus*, it was never seen under stones at the margin of the lake. Specimens were found at all times of the year and the species is evidently able to tolerate changes in specific gravity varying from 1·000 to 1·0265. Ovigerous females were found in November and March. In the former of these months they occurred in water of very slight salinity, whereas in the latter months they were obtained in water as salt as that of the sea in the neighbourhood of the lake-mouth.

The type specimens bear the nos. 9020-2/10 in the Museum register.

Family ATYIDAE.

Genus **CARIDINA,** Milne-Edwards.

1905. *Caridina*, Bouvier, *Bull. sci. France Belgique*, XXXIX, p. 67.
1913. *Caridina*, Bouvier, *Trans. Linn. Soc., Zool.* (2), XV, p. 447.

Two species of this genus are commonly found in the Chilka Lake among weeds. Both occur abundantly in the Gangetic delta in brackish water.

Caridina nilotica (Roux).

var. **bengalensis,** de Man.

1908. *Caridina nilotica*, var. *bengalensis*, de Man, *Rec. Ind. Mus.*, II, p. 265, pl. xx, figs. 6, 6*a*, 6*b*.

For the form of *Caridina nilotica* which occurs in the Chilka Lake I have employed the varietal name given by de Man to the race found in the Gangetic delta.

There are numerous series of *Caridina nilotica* in the Indian Museum obtained at various points on the coasts of the Indian peninsula. Where precise data are available, it appears that these specimens were, with very few exceptions, obtained in brackish water or in water that, though fresh at the time of their capture, is occasionally subject to tidal influence.

These series of individuals all agree in possessing the characters of the var. *bengalensis* except that they show considerable variation in the dentition of the rostrum. Even in examples from the Gangetic delta the range of variation is much greater than is apparent from de Man's account, the teeth forming the basal crest on the upper margin varying in number from 15 to 30 and those on the lower margin from 11 to 22. On examining long series from different places it is evident that local distinctions exist in the number of rostral teeth; but these distinctions are so slight that it is only by taking the average of a large number of individuals that they can be detected and they are, of course, far too trivial to justify nominal recognition.

It is, however, interesting to note that the Chilka Lake examples agree more nearly with those from S. India than with those from the Gangetic delta, a fact which is shown in the following table:—

	Calcutta (Garia).	Chilka Lake.	Madras (Villy-vakkam).	Tuticorin.	Colombo.
No. of specimens examined	149	100	200	34	91
Dorsal teeth of rostrum, basal crest only ..	15—30	14—25	14—27	15 23	13—23
Ventral teeth of rostrum	11—22	6—19	9—20	11—19	8—18
Average no. of dorsal teeth	22·7	19·1	19·7	19·0	16·8
Average no. of ventral teeth	14·7	12·0	13·6	15·6	13·2
Length of eggs (mm.)	·41—·48	·42—·48	·42—·49	·47—·475	·43

In his work on the varieties of *C. nilotica*, de Man notes that var. *bengalensis* is very closely related to var. *gracilipes*, de Man, a form found in Celebes and Saleyer. From this race the Indian form is separated by the greater number of teeth on the upper edge of the rostrum and by the larger size of the eggs; but it seems probable that a distinction based on these grounds is untenable. The number of dorsal teeth in Indian specimens ranges from 13 to 30 and in var. *gracilipes* from 12 to 20. In the former the average number varies from 16·8 in the case of Ceylon specimens to 22·7 in the case of individuals from the vicinity of Calcutta, while in the latter, according to the results of de Man's examination of twenty-five specimens[1], the average number is about 15·8. The eggs vary in length from ·33 to ·40 mm. in var. *gracilipes* and from ·41 to ·49 in var. *bengalensis*.

Should it prove that no other distinctions are available, the name *gracilipes* must be used for the Indian form.

In the Chilka Lake *Caridina nilotica* was found only in Rambha Bay and in the outer channel; but in both these localities it was abundant. In Rambha Bay it was plentiful among weed near the margin of the lake and was also found near the rocks at the foot of Ganta Sila. Ovigerous females were taken both in February in water of sp. gr. 1·011 and in September in water of sp. gr. 1·006.

In the outer channel it was obtained in February at Satpara and near Mahosa in water as salt as that of the Bay of Bengal near the lake (sp. gr. 1·0265), but no females bearing eggs were to be found. In September when the water was fresh and stood at a level some 5 ft. higher than in February, the species was common in the same localites, living among the roots of screw-pines, and was also found in submerged grass on islands near Manikpatna. At this time of the year numerous egg-laden females were obtained. Our observations seem to indicate that very saline water inhibits reproduction.

The absence of *C. nilotica* from the vicinity of Barkul and from other places in the main area where weed is plentiful and the conditions apparently favourable is perhaps to be explained by the enormous abundance of *C. propinqua* in these localities. This prolific species has perhaps ousted *C. nilotica* from situations in which it would otherwise have occurred.

[1] de Man, in *Weber's Zool. Ergebn. Niederländ. Ost-Ind.*, II, p. 394 (1892).

Caridina nilotica, sensu lato, is known from an area extending from N. and S. Africa to Celebes.

Caridina propinqua, de Man.

1908. *Caridina propinqua*, de Man, *Rec. Ind. Mus.*, II, p. 227, pl. xix, figs. 6, 6*a*—*f*.
1913. *Caridina propinqua*, Bouvier, *Trans. Linn. Soc., Zool.* (2), XV, p. 463.

The specimens of this species from the Chilka Lake agree closely with de Man's description and with individuals from the Gangetic delta.

According to de Man the species is allied to *Caridina fossarum*, Heller, and *C. laevis*, Heller; but these two forms are widely separated from *C. propinqua* in the valuable key to certain species of the genus which Bouvier has recently supplied. *C. propinqua*, in Bouvier's table, is distinguished from *C. laevis*, *C. fossarum* and numerous other species by the comparatively greater length of the antennular peduncle. This character is not easily determined with accuracy; but comparison between *C. laevis* (of which Javanese specimens are available) and *C. propinqua* indicates that in these two forms it affords a valid distinction.

As regards the rostral dentition, in 50 specimens from the Chilka Lake there are from 10 to 17 dorsal teeth (average 13·6) and of these from 2 to 5 (usually 3) are placed behind the orbit. On the ventral margin there are from 0 to 3 teeth (average 1 5). In examples from the Gangetic delta the teeth are as a rule rather more numerous. In 50 individuals from Durgapur the dorsal teeth vary in number from 9 to 22 (average 16·7) with from 2 to 5 (usually 4) situated on the carapace behind the orbit. On the ventral margin there are from 0 to 4 teeth (average 1·8).

There is also a slight difference between specimens from the two localities in the form of the first pair of peraeopods, these limbs being a trifle more slender in the Gangetic form than in that found in the Chilka Lake. The distinction is, however, too trifling to be expressed by means of measurements.

In both forms the propodus of the last leg is about 2·4 times the length of the dactylus and no differences are to be found in the number of dactylar and uropodial spines and other characters enumerated by de Man.

The eggs are of the same size as in individuals from the Gangetic delta; they vary from 0·51 mm. in length and 0·32 mm. in breadth when first extruded, to 0·6 mm. in length and 0·38 mm. in breadth, when on the point of hatching.

Caridina propinqua occurs in all parts of the main area of the Chilka Lake throughout the year and is especially abundant in thickets of *Potamogeton* off Cherria I., in Barkul Bay and near Nalbano. In the outer channel it was obtained only in the freshwater season (September) and then in no great abundance, specimens being found in Seruanaddi and, in company with *C. nilotica*, among roots of screw-pines near Arupatna and in submerged grass on the islands near Manikpatna.

In the main area the species appears to breed throughout the year; ovigerous females were obtained in the months of January, February, March, July, September and November. A few egg-laden females were also found in September in the outer channel.

From the records available it seems that *C. propinqua* is found only at the northern end of the Bay of Bengal. In addition to samples from the Chilka Lake and the Gangetic delta we have specimens from Chittagong, from Cuttack and, in the vicinity of Puri, from Athara nullah and the Sar Lake. The individuals from the last named locality and from Cuttack were obtained in water that remains permanently fresh; but the species is more usually found in places subject to tidal influence.

Family PASIPHAEIDAE.

Genus LEPTOCHELA, Stimpson.

1860. *Leptochela*, Stimpson, *Proc. Acad. Sci. Philadelphia*, XII, p. 42.
1896. *Leptochela*, Caullery, *Ann. Univ. Lyon*, XXVI, p. 372.

The species of this genus found in the Chilka Lake is also common in suitable localities on other parts of the Indian Coast and, as in *L. carinata*, Ortmann, from the Atlantic coast of America shows marked sexual distinctions. In the female the carapace bears a distinct median carina with an additional carina of considerable length on either side of it, whereas in the male the median carina is less distinct and the lateral carinae are wanting. This sexual distinction may be proper to several other species of the genus, a fact which should be borne in mind when the character is used for the discrimination of allied forms.

The following five species of *Leptochela* have been described; the first two from the Atlantic coast of America, the remainder from the Indo-pacific:—

1. *Leptochela carinata*, Ortmann[1]: distinguished by the presence of four teeth on the mid-dorsal carina of the fifth abdominal somite.

2. *Leptochela serratorbita*, Bate[2]: distinguished by the finely serrated or spinulose orbital margin.

3. *Leptochela gracilis*, Stimpson[3], the type species of the genus: distinguished by the presence of a sharp tooth at the distal end of the carina on the fifth abdominal somite. A fresh account of this species is badly needed. It is not certain that the specimens recorded under this name by Bate[4] are correctly identified.

4. *Leptochela robusta*, Stimpson, cannot be recognised with any certainty from the original description.[5] Bate's[6] subsequent account and figures are probably unreliable, but de Man's detailed description of a single male from Ternate[7] will afford a useful basis for future work. I am not convinced that the Hawaiian specimens

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[1] Ortmann, *Decap. Schizop. Plankton-Exped.*, p. 41, pl. iv, fig. 1 (1893) and Rathbun, *Bull. U.S. Fish Comm. for* 1900, XX, 2, p. 127 (1902).

[2] Bate, *Rep. 'Challenger' Macrura*, p. 859, pl. cxxxix, fig. 1 (1888) and Rathbun, *Bull. U.S. Fish Comm. for* 1900, XX, 2, p. 127 (1902).

[3] Stimpson, *loc. cit. supra*, p. 42.

[4] Bate, *Rep. 'Challenger' Macrura*, p. 860, pl. cxxxix, fig. 2 (1888).

[5] Stimpson, *loc. cit., supra*, p. 43 (1860).

[6] Bate, *Rep. 'Challenger' Macrura*, p. 862, pl. cxxxix, figs. 3, 4 (1888).

[7] de Man, *Abhandl. Senckenb. naturf. Ges. Frankfurt*, XXV, p. 902.

recorded by Miss Rathbun[1] are specifically identical with that described by de Man. The species, which should bear the name of *L. robusta*, Stimpson (de Man), is apparently characterized by the absence of the special features that distinguish *L. carinata*, *L. serratorbita* and *L. gracilis* and by the presence of three pairs of spinules on the dorsal surface of the telson in addition to those at the apex.

5. *Leptochela aculeocaudata*, Paulson[2], is probably a close ally of *L. robusta*, from which it is distinguished by the presence of only two pairs of spinules on the dorsal surface of the telson in addition to those at the apex.

Leptochela reversa, Bate[3], is apparently a *nomen nudum*.

The Indian form is provisionally identified with *L. aculeocaudata*, a determination which premises a considerable amount of error in Paulson's figures and that the marked sexual differences in the carination of the carapace escaped his notice.

Caullery (*loc. cit. supra*) in his account of the Decapoda collected by the 'Caudan' expedition has provided a valuable key to the five more well-established genera of Pasiphaeidae. *Leptochela* is distinguished from other genera by the possesion of a mandibular palp composed of a single segment and by the presence of laciniae on the inner margin of the second maxilla.

The branchial formula in the Indian species is apparently identical with that found in *Parapasiphaē*, Smith :—

	VII.	VIII.	IX.	X.	XI.	XII.	XIII.	XIV.
Podobranchiae ..	ep.	ep.	ep.	..	..	..	..	..
Arthrobranchiae ..	..	..	2	I	I	I	I	..
Pleurobranchiae ..	..	..	..	I	I	I	I	I

Leptochela aculeocaudata, Paulson.

(Plate XIII, fig. 14.)

1875. *Leptochela aculeocaudata*, Paulson, *Crust. Red Sea*, p. 100, pl. xvi, fig. 1.
1906. *Leptochela aculeocaudata*, Nobili, *Ann. Sci. nat. Paris*, (9), IV, p. 28, text-figs. 4*a-c*.

In dorsal view the rostrum is broad at the base, but narrows rapidly to a sharp apex. It is very short; in the male it reaches only to the middle of the cornea, while in the female it is rather longer and may reach to the end of the eyes; it is occasionally a little upturned at the apex. The rostrum bears a longitudinal dorsal carina which extends backwards on the carapace. In the male this carina is not sharp and disappears altogether before reaching the middle of the carapace. In the female (pl. xiii, fig. 14) it is much more conspicuous and is continued to the middle of the posterior quarter of the carapace as a thin compressed keel. In this sex there

[1] Rathbun, *Bull. U. S. Fish Comm. for* 1903, XXIII, p. 929 (1906).

[2] Paulson, *Crust. Red Sea*, p. 100, pl. xvi, fig. 1 (1875) and Nobili, *Ann. Sci. nat., Zool.* (9), IV, p. 28, text-figs. 4, *a-c* (1906).

[3] Bate, *Rep. 'Challenger' Macrura*, p. 722 (1888).

is also a smoothly rounded ridge on either side of the median carina, running parallel with it and commencing near the upper part of the orbital margin. In the male these ridges are non-existent. The carapace is strongly compressed and, as in other species of the genus, the posterior margin is deeply excavate mid-dorsally. The orbital and antero-lateral angles are bluntly rounded.

The eyes are short and globular, the breadth of the cornea being much greater than that of the stalk. The antennular peduncle (text-fig. 34*a*) reaches a little beyond the middle of the antennal scale. In lateral view the basal process is lanceolate in shape; its margins bear long setae and the apex reaches to the distal end of the segment to which it is attached. The third segment is longer than the second. The two antennular rami are stouter in the male than in the female. The outer ramus is

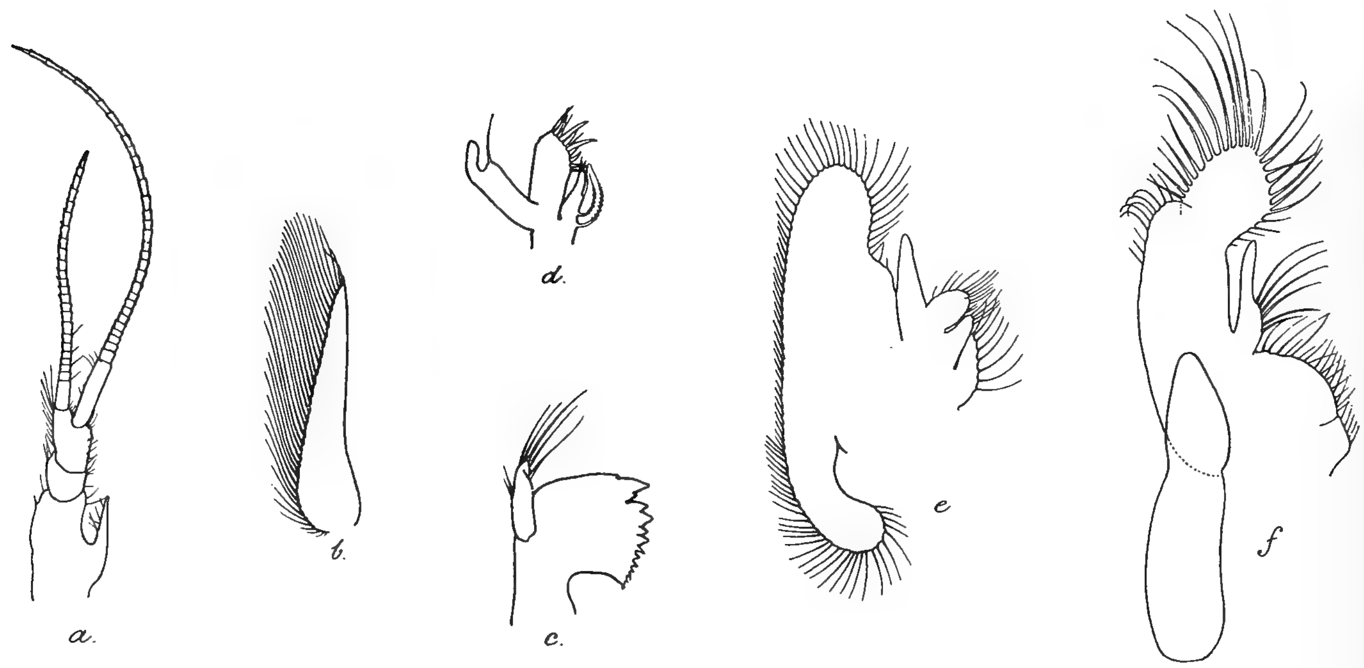

Fig. 34.—*Leptochela aculeocaudata*, Paulson.

a. Antennule of female. *d.* First maxilla.
b. Antennal scale. *e.* Second maxilla.
c. Mandible. *f.* First maxillipede.

the longer; when flexed backwards it reaches to the end of the carapace in the female and about to the middle of the third abdominal somite in the male.

The antennal scale (text-fig. 34*b*) is narrowly triangular, about four times as long as broad, the lamella at the distal end sloping rapidly away from the base of the terminal spine. The outer margin is sinuous in both sexes, concave behind the middle point and slightly convex onwards to the apex.

The cutting edge of the mandible (text-fig. 34*c*) in its outline resembles Paulson's figure, but bears from 12 to 15 teeth. It is not cleft in the middle as, according to Stimpson's account, it is in *P. gracilis*. The palp is composed of a single segment, somewhat expanded laterally and furnished with setae on its margins. Three laciniae are well developed on the inner edge of the second maxilla (text-fig. 34*e*).

The first maxillipede (text-fig. 34*f*) bears a large bilobed epipod (not shown in

Paulson's figure) and a curious rounded lobe on the external margin of the exopod near its apex. On the second maxillipede[1] (text-fig. 35*a*) there is a small epipod, but no exopod. The last two segments of the endopod bear conspicuous spines; the ultimate segment is acutely produced at the apex.

The third maxillipedes (text-fig. 35*b*) reach about to the end of the antennular peduncle and bear both epipod and exopod, the latter reaching the distal end of the antepenultimate segment. The ultimate segment bears a few stout setae at its apex and is a little shorter than the penultimate.

The first and second peraeopods (text-figs. 35*c, d*) reach about to the end of the antennal scale, the latter pair being slightly longer than the former. The exopod of the first pair reaches nearly to the end of the ischium; that of the second pair is a trifle shorter. The ischium is longer than the merus and decidedly shorter than the chela. The palm is about one and a half times the length of the carpus and the fingers are almost or quite one and a half times the length of the palm. On the inner edges of the fingers are numerous forwardly directed spinules, three or four of which are noticeably longer than the others. The spinulation on the lower edges of the segments varies according to sex; but in both male and female there are two or three large spinules on the basis. In the female there are a number of large spinules on the inferior margins of the merus, carpus, palm and dactylus; in one specimen in which they appear to be specially well developed there are 6 on the merus, 4 on the carpus, 5 on the palm and 6 on the dactylus. In the male the spinules are smaller and appear to be less numerous. There is always a strong spinule at the upper distal end of the ischium.

The third peraeopods (text-fig. 35*e*) reach to the carpus of the second pair; the exopod extends a little beyond the middle of the ischium. The ischium is the longest segment, its length exceeding that of the two following combined. The propodus is one half the length of the merus, nearly twice the length of the carpus and fully one and a quarter times as long as the dactylus. On the upper edge there are long setae at the distal end of the ischium and on the merus; on the lower edge there are numerous setae on all the segments and 3 spinules on the ischium, 4 on the merus and 1 on the carpus.

The fourth and fifth peraeopods are much reduced and do not reach the anterior margin of the carapace. The fourth legs (text-fig. 35*f*) are remarkable for the large ventral spine borne by the ischium. This spine slopes strongly forwards and, just in advance of its base on the protruding margin of the segment, are two small movable spinules (text-fig. 35*g*). The apparatus is perhaps used for cleaning the appendages, acting as a comb. The exopod reaches a little beyond the end of the ischium. The merus and carpus are subequal in length, a little longer than the ischium. The dactylus is five sevenths the length of the carpus and one sixth longer than the propodus,

[1] Paulson's figure of this appendage seems to be wholly erroneous. Owing to faulty dissection he has in one of his preparations confounded the first and second maxillipedes, the exopods of the former appearing as a portion of the latter.

the latter segment being less than two and a half times as long as wide. There are stout setae on the ventral margins of all the segments except the ischium and, on the upper margin, on the carpus and at the distal ends of the ischium and merus.

In the fifth pair (text-fig. 35*h*) the exopod is short and broad, not reaching much beyond the middle of the ischium. The merus and carpus are subequal in length, about one and a half times the length of the propodus. The latter segment is a little shorter than the dactylus. On the ventral margins of the ischium and

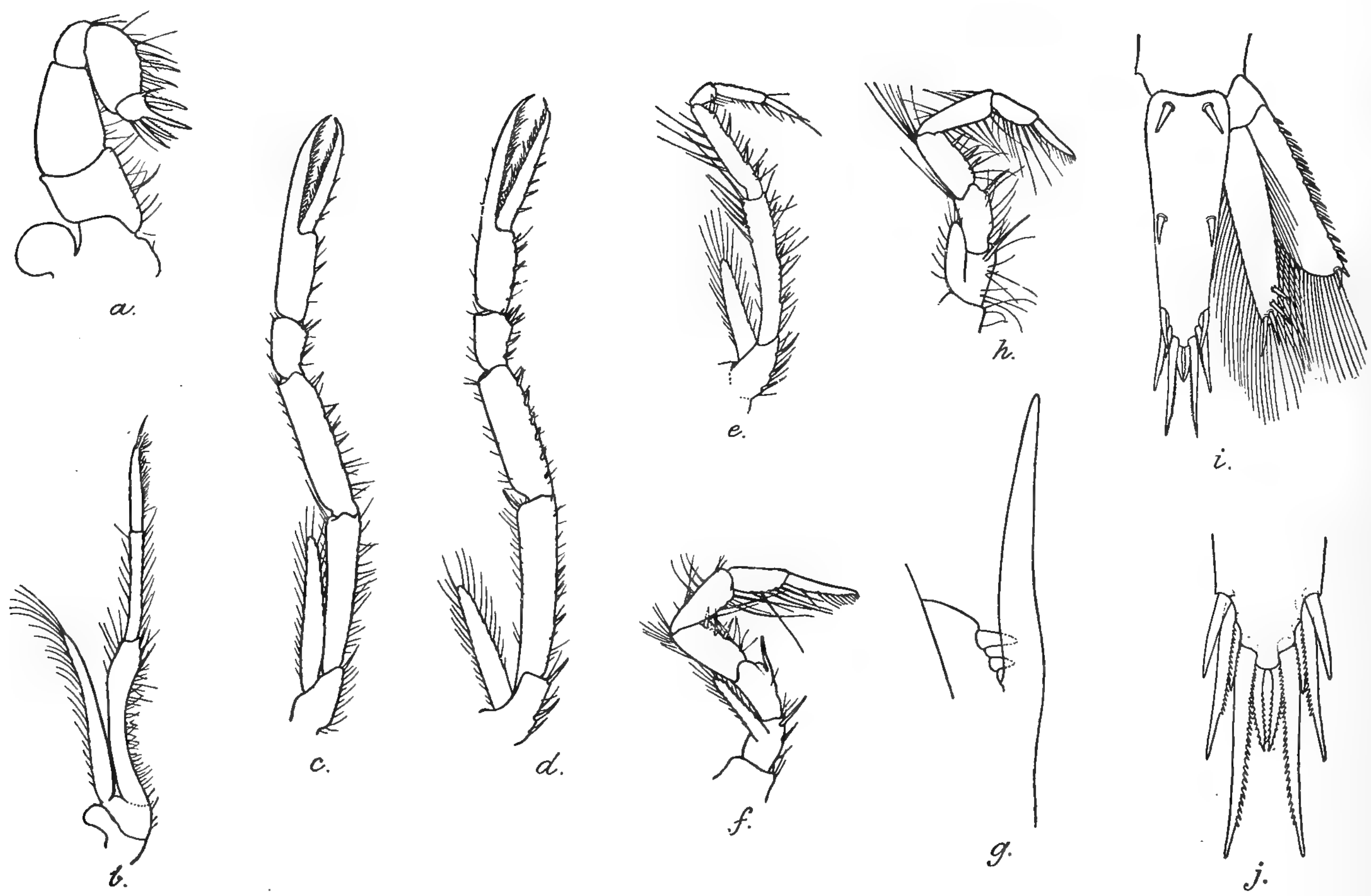

FIG. 35.—*Leptochela aculeocaudata*, Paulson.

a. Second maxillipede.
b. Third maxillipede.
c. First peraeopod.
d. Second peraeopod.
e. Third peraeopod.
f. Fourth peraeopod.
g. Spines on lower margin of ischium of fourth peraeopod, further enlarged.
h. Fifth peraeopod.
i. Telson with outer and inner uropods.
j. Apex of telson, further enlarged.

merus there is, among others of more slender build, a single stout seta; otherwise the limb is clad in setae much as in the fourth pair.

The first four abdominal somites are smoothly rounded dorsally; the pleura of the first two are greatly enlarged in the female. The fifth somite is very obscurely carinate in the mid-dorsal line, but the carina is not produced posteriorly as a spine. The sixth somite is smoothly rounded above; at its anterior end there is a short transverse ridge on the dorsal surface which, in lateral view, has the apearance of a tubercle. On the posterior margin there is a pair of small spinules, one on either side, overhanging the articulation of the telson. The ventral margins are fringed with

setae, among which, in the posterior half of each, a sharp backwardly directed spine may be detected.

The telson (text-fig. 35*i*) reaches beyond the end of the uropods and is strongly sulcate above. Apart from those at the apex there are only two pairs of dorsal spines; the first pair is situated near the anterior margin of the telson; the second about in the middle of its length. At the apex are *five* pairs of spines, the respective lengths of which are shown in text-fig. 35*j*.[1] Except for the outermost, all these spines are internally pectinate, the innermost being also pectinate externally.

The outer uropod is a little more than three times as long as wide. The straight outer margin terminates in two spines in front of which are from 8 to 11 additional spines interspersed among fine setae. At the apex of the inner uropod on its dorsal side there are also three or four slender spines.

Large specimens attain a total length of about 16 mm.

Indian specimens differ in several points from Paulson's figures and from the translation of his description which Nobili has supplied. The individual drawn by Paulson in fig. 1 is apparently a female and, if I am right in assuming that the Indian examples belong to the same species, the lateral ridges on the carapace on either side of the middle line are incorrectly shown. These ridges should be parallel and should extend further backwards.

Leptochela robusta, Stimpson, judging from de Man's account of a single male[2], is apparently a very close ally of *L. aculeocaudata*; but, apart from less conspicuous details, differs from it in the armature of the telson. According to de Man's description there are in this species three pairs of spines on the upper surface of the telson, the posterior pair situated about in the middle of its length. In *L. robusta*, also, there are four pairs of spines at the apex of the telson in place of the five found in *L. aculeocaudata.*

In life specimens are transparent with the oral appendages, the bases of the thoracic limbs and pleopods, the hinder half of the last abdominal somite and telson bright red. The carapace, abdomen, antennae, antennules, uropods and the greater part of the thoracic and abdominal appendages are colourless. The eggs are opaque and whitish.

Of *Leptochela aculeocaudata* only a single individual was found in the Chilka Lake. It was obtained in the outer channel near Barhampur I. in March in water of specific gravity as high as that of the Bay of Bengal in the vicinity of the lake (1·0265). The species is clearly no more than a casual visitor to the lake.

There are numerous other examples of the species in the Indian Museum. In 1889 the R.I.M.S. 'Investigator' obtained a specimen 3 miles E.S.E. of Puri (a position not far distant from the mouth of the Chilka Lake) at a depth of 10 fms.

[1] The spines of the third pair are shorter than the second and fourth and are partially concealed by them.

[2] *loc. cit., supra*, p. 310

More recently the 'Investigator' found the species in large numbers in the Mergui Archipelago (lat. 11°58′20″ to 12°48′ N.; long 98°16′10″ to 98°26′30″ E.) at depths varying from 8 to 24 fms. During the present year I found a number of specimens, mostly on a muddy bottom, at Port Blair in the Andamans in from 1 to 10 fms. and in 1913 obtained a few examples in shallow water among weeds at Kilakarai in the Ramnad District at the northern end of the Gulf of Manaar.

The species has hitherto been recorded only from the Red Sea.

Tribe PENAEIDEA.

Family PENAEIDAE.

Five species belonging to this family occur in the Chilka Lake. Four of them are abundant and are caught in large numbers by the Uriya fishermen in special traps, which will be described in a subsequent paper in this volume. The trap depends for its efficacy on the habits of the prawns, which travel at night along the shore in very shallow water. If they meet with any obstruction they make their way along it and are thus, by means of training fences, easily led into an enclosure surrounded by traps, into the apertures of which they apparently force themselves on the approach of daylight. On Barnikuda I. there is a factory in which Penaeid prawns are dried for export, the greater part of the supply finding its ultimate destination in Burma.

The little knowledge we at present possess of the prawn fisheries in the Gangetic delta tends to show that there is an annual migration of Penaeidae to the sea. This migration takes place in the winter months and apparently coincides with the beginning of the breeding season.[1] In the Chilka Lake we found no clear evidence of migrations; three at least of the species are found throughout the year, but it is tolerably certain that none of them breed in the lake. The shallow waters of the main area with the dense beds of weed that exist in many parts would seem to afford an admirable nursery for young Penaeids. In such localities, however, we failed to find them: all the young specimens in our collection were obtained in the outer channel. It is only to adolescent prawns that the main area of the lake is attractive; early post-larval stages are seemingly unable to withstand the changes in salinity, while the fact that no very large specimens were obtained (though individuals with well-developed secondary sexual characters are not uncommon) tends to show that after they have returned to the sea for breeding purposes they do not again re-enter the lake.

Thanks to Alcock's memoir on the Indian prawns of the *Penaeus* group, the characters of most of the Indian species are now well known; but more recent work has unfortunately made necessary a number of changes in the nomenclature that he adopted.

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[1] On the British coasts somewhat similar migrations are known in the case of *Pandalus montagui* [*v.* Kemp, *Fisheries, Ireland, Sci. Invest. for* 1908, p. 87 (1910)].

Genus **PENAEUS,** Fabricius (Smith).

1906. *Peneus,* Alcock, *Cat. Indian Decap. Crust.*, III, i, p. 4.
1911. *Penaeus,* de Man, *Decap. 'Siboga' Exped.*, I, *Penaeidae,* p. 95.

De Man's examination of the type specimen of *Penaeus semisulcatus,* de Haan, has had unfortunate consequences, for it involves an alteration in the names given by Alcock to two of the most abundant Indian species of the genus.

Alcock's *Penaeus semisulcatus,* the common salt-water prawn of the Calcutta markets, is shown to be specifically different from that described in the Fauna Japonica and is identified by de Man (though the determination is perhaps open to question) with Dana's *P. carinatus.* The form described by Alcock under the name of *P. monodon,* Fabricius, is however identical with de Haan's *semisulcatus*: the points of distinction which de Man notices (*loc. cit.*, p. 98) between de Haan's type and Alcock's figures have no real existence, a fact which I have been able to determine by an examination of Indian specimens and by comparison with Japanese examples received from Prof. Kishinouye under the name of *P. ashiaka.*

The description that Fabricius gave of his *Penaeus monodon* is insufficient for its recognition; but it was found in Indian seas and it is clear that the name must belong to one of the three forms which, in de Man's memoir, are referred to as *P. semisulcatus, P. carinatus* and *P. indicus.* De Man has not associated any species with the Fabrician name and it is probably best that it should be ignored, though the possibility that the type specimen still exists must remain a menace to the stability of the revised nomenclature.

Two species of *Penaeus, P. carinatus,* Dana (de Man) and *P. indicus,* M.-Edw., are common in the Chilka Lake. They are to be found at all seasons of the year both in the main area and in the outer channel and are able to exist in water varying in specific gravity from 1·000 to 1·0265.

Penaeus carinatus, Dana (de Man).

1906. *Peneus semisulcatus,* Alcock (not of de Haan), *Cat. Indian Decap. Crust.*, III, i, p. 10, pl. i, fig. 2.
1911. *Penaeus carinatus,* de Man, *Decap. 'Siboga' Exped.*, I, *Penaeidae,* p. 101.

The precise meaning of de Man's statement (*loc cit.*, p. 102, end of para. 1) is not quite clear to me. As I understand it, he implies that, should the identity of Alcock's *monodon* and de Haan's *semisulcatus* be established, he would consider it justifiable to use the name *monodon* for the species which he himself records as *P. carinatus,* Dana. As stated above, I have been able to establish the identity he postulates; but, now that Alcock's application of *monodon* is shown to be incorrect, I do not think it can safely be used for any other species.

It is a choice of evils. As the matter rests at present, it seems to me better to employ the term *carinatus,* as a provisional measure, and one less liable to cause confusion than that consequent on a re-introduction of the name *monodon* in a new sense and without any certainty that its application would be well-founded. Even

de Man's identification of *P. carinatus* is, however, open to criticism, for Dana neither figures nor mentions the subhepatic crest of the carapace. It is most unfortunate that the correct name of this species, the common prawn of the Calcutta markets, must still remain uncertain.

Adults of the species are deeply pigmented with a tint varying from olive green to deep bluish-grey, usually the latter in large examples, with darker transverse bars on the abdomen. The colouring is sometimes almost as bright as in Stebbing's figure[1] of *P. caeruleus*; the bars have the same distribution, but are always more conspicuous in life. The outer surface of the protopodite of each pleopod is invariably bright lemon yellow, a distinctive feature not shown in Stebbing's figure and hardly indicated in that which Kishinouye has given of *P. monodon*[2] (a synomym of *P. carinatus*).

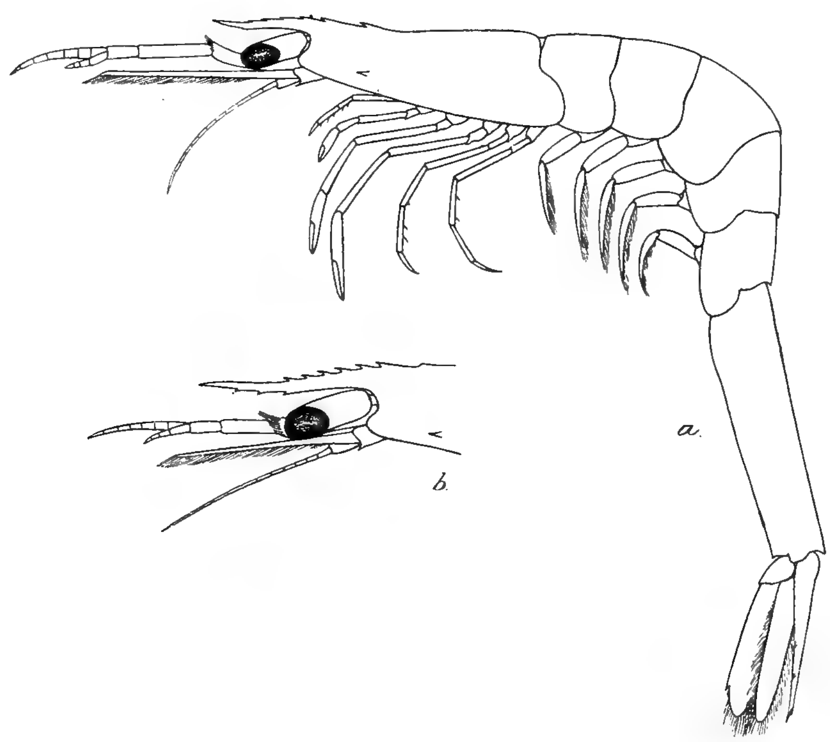

FIG. 36.—*Penaeus carinatus*, Dana (de Man).

a. Pelagic post-larval stage.
b. Rostrum, eyes, etc. of a somewhat older specimen.

In young specimens some 2 or 3 inches in length the colour is pale grey with a dark green mottling among which the transverse bars of the abdomen are only detected with difficulty. The yellow patches on the pleopods are absent.

[1] Stebbing, *Marine Invest. S. Africa*, IV, pl. xxi *bis* (1905). *P. caeruleus*, according to Stebbing, does not possess an exopod at the base of the last legs; but de Man has found this appendage in one of the type specimens and queries *P. caeruleus* as a synonym of de Haan's *semisulcatus*. I have never seen a fresh specimen of the latter and consequently have no knowledge of its colouration. Stebbing notes that the integument of *P. caeruleus* "has the property of retaining for years in preservative media (spirit and formalin) the fascinating blue colour to which the specific name refers." This is certainly not the case with *P. carinatus*: specimens turn red after only a day's immersion in alcohol.

[2] Kishinouye, *Journ. Fish. Bureau Tokyo*, VIII, pl. ii, fig. 1 (1900). The figure appears to have been coloured from a preserved specimen.

Still younger post-larval individuals, which I believe are correctly referred to this species, differ from those of all allied forms with which I am acquainted in their extremely slender build (text-figs. 36*a*, *b*). When very young, about 10 mm. in length, they are pelagic and are transparent with a crimson streak running along the ventral surface involving the whole of the antennules and the telson, but not the other appendages, except to a slight extent the uropods.[1] They possess two pairs of lateral spines on the telson and the rostrum, which in the youngest individuals is without inferior teeth, reaches a little beyond the eyes.

Rather larger post-larval specimens still retain their slender build, but are deeply mottled with dark grey and dull green and live among weeds. Both colour and form are doubtless protective, as in Hippolytids of the genus *Tozeuma*, to which these post-larval Penaeids bear a curious resemblance. When captured they are very conspicuous, for, apart from the attenuated form, their deep colouration readily distinguishes them from other species with which they are associated. These, as a rule, consist of other young Penaeidae, young Palaemonidae and *Caridina*, all of which are semitransparent and but little pigmented.

Penaeus carinatus is to some extent a migratory species. I am inclined to think that it ascends estuaries and makes its way into water of low salinity only at those seasons in which it is not breeding. It is practically absent from the Calcutta markets for several of the winter months, the supply for this market coming entirely from brackish water. The pelagic post-larval form, which was common in the Ennur backwater near Madras in January, was obtained in the Chilka Lake only in the outer channel in the salt-water season. The latter non-pelagic stage is not uncommon in the vicinity of Calcutta in early spring, but, strangely enough, is not represented in our collection from the Chilka Lake. The pelagic form is apparently carried by the tide well up into the Gangetic delta and settles down in weedy pools and backwaters many miles from the sea, to which the adults annually resort at the breeding season.

In the Chilka Lake *P. carinatus* was less abundant than some other species of Penaeidae; it was, however, found both in the main area and in the outer channel and occurred in both regions at all seasons of the year. It is certainly able to exist for considerable periods in water that is quite fresh.

The species has a recorded distribution ranging from Japan to Karachi.

Penaeus indicus, Milne-Edwards.

1906. *Peneus indicus*, Alcock, *Cat. Indian Decap. Crust.*, p. 12, pl. i, figs. 3, 3*a*.

1911. *Penaeus indicus* var. *longirostris*, de Man, *Decap. 'Siboga' Exped.*, I, *Penaeidae*, p. 103 and (1913) pl. ix, figs. 32*a*, *b*.

The variety *longirostris*, described by de Man, is based entirely on the length of the rostrum and the great degree of variation that Indian specimens exhibit in this

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[1] *P. gracilis*, Dana, *U. S. Explor. Exped., Crust.*, I, p. 606, pl. xl, figs. 7*a*, *a'*, *b* (1852) is apparently a related post-larval form.

respect leads me to believe that the varietal name cannot be retained. The largest examples from the Chilka Lake do not exceed 120 mm. in length and, in them, the rostrum exceeds the tip of the antennal scale by one-fourth or one-fifth of its length.

In life the general colour is translucent whitish, with numerous small brownish, greyish, or greenish chromatophores scattered over the carapace and abdomen. The upper half of the rostrum, base of the eyestalks, dorsal carinae of the last three abdominal somites, telson and uropods are deeply pigmented with maroon and dull brown chromatophores. The antennae and the terminal parts of the exopods of the second and third maxillipedes are pinkish; the tips of both uropods and the external margins of the outer pair are pinkish-red with similarly coloured setae. The antennular flagella are lemon yellow, banded and dotted with maroon.

In the Chilka Lake *P. indicus* is more abundant than *P. carinatus*. It is caught in large numbers by the Uriya fishermen and occurs at all seasons of the year both in the main area and in the outer channel. In the latter region a young form was taken in abundance which must, I believe, be referred to this species. In life it is semitransparent, sparsely pigmented with brown; the rostrum is very long, toothed both above and below. It does not present the attenuated appearance of late post-larval individuals of the preceding species. Unfortunately no specimens corresponding to the pelagic stage of the latter were obtained.

P. indicus appears to have a distribution extending from E. Africa and the Red Sea to China, but not reaching Japan.

Genus PENAEOPSIS, Bate.

1881. *Penaeopsis* (A. Milne-Edwards, MS.), Bate, *Ann. Mag. Nat. Hist* (5), VIII, p. 182.
1891. *Metapenaeus*, Wood-Mason, *Ann. Mag. Nat. Hist.* (6), VIII, p. 271.
1906. *Metapeneus*, Alcock, *Cat. Indian Decap. Crust.*, III, i, p. 16.
1909. *Penaeopsis*, A. Milne-Edwards and Bouvier, *Mem. Mus. Comp. Zool. Harvard*, XXVII, p. 220.
1911. *Penaeopsis*, de Man, *Decap. 'Siboga' Exped.*, I, *Penaeidae*, p. 53.

Bate's description of this genus is worthless; but it is clear from the work of A. Milne-Edwards and Bouvier (1909) that *P. serratus*, the type species of the genus, is indistinguishable generically from the forms on which Wood-Mason based his *Metapenaeus*. The latter name must consequently lapse.

Three species of this genus occur in the Chilka Lake. Two of them, *P. monoceros* (Fabr.) and *P. dobsoni* (Miers) are abundant and are found throughout the year both in the main area and in the outer channel. The third, *P. affinis* (A. M.-Edw.), is apparently scarcer; though not found in the outer channel there can be little doubt that it occurs there, for specimens were obtained at all seasons in the main area and numerous examples were recorded by Alcock from the 'Investigator' dredgings on the Orissa coast. All three forms are evidently able to exist in water of specific gravity varying from 1·000 to 1·0265; but I think it improbable that any of them breed in the lake. Species of this genus were more frequently caught in our bottom nets in the middle of the main area than those of *Penaeus*.

Penaeopsis monoceros (Fabricius).

1906. *Metapeneus monoceros*, Alcock, *Cat. Indian Decap. Crust.*, III, i, p. 18, pl. iii, figs. 7, *7a-c*.
1911. *Penaeopsis monoceros*, de Man, *Decap. 'Siboga' Exped.*, I, *Penaeidae*, p. 55, and (1913) pl. vi, figs. 14*a*, *c*.

The small tooth at the distal extremity of the ischium of the first peraeopods, mentioned by de Man (*loc. cit.*, p. 56) is present in Indian examples of this species.

P. monoceros is very abundant in the Chilka Lake and is brought into the local markets in large numbers. It occurs both in the main area and in the outer channel at all seasons of the year.

In life specimens are semitransparent, closely covered with small red chromatophores. The dorsal carina of the carapace, the rostrum, the bases of the eyestalks, the dorsal abdominal carinae and the carinae of the telson and uropods are defined by dull red pigmentation. The antennae are bright red, the first two legs colourless, the last three with numerous red chromatophores. The setae that fringe the uropods are golden red and the outer uropod is bright red along its external margin. The nerve-cord is sheathed in red pigment and is clearly visible from beneath.

The species is known from an area extending from the Indus delta to Hongkong and Japan and perhaps also occurs in Australia.

Penaeopsis affinis (A. Milne-Edwards).

1906. *Metapeneus affinis*, Alcock, *Cat. Indian Decap. Crust.*, III, i, p. 20.
1911. *Penaeopsis affinis*, de Man, *Decap. 'Siboga' Exped.*, I, *Penaeidae*, p. 57, and (1913) pl. vi, figs. 15*a*, *b*.

At the time of their capture specimens of this species were not distinguished from *P. monoceros*. In the collection are some twenty individuals, the largest, about 105 mm. in length, obtained in February and March at various localities in the main area between Rambha and Kalidai I. *P. affinis* is recorded by Alcock from 'Investigator' dredgings on the Orissa Coast; it therefore doubtless occurs in the outer channel and it is probable that, like *P. monoceros* and *P. dobsoni*, it is to be found in the lake at all seasons of the year.

The species is known to be distributed over an area extending from the Indus delta to Japan.

Penaeopsis dobsoni (Miers).

1906. *Metapeneus dobsoni*, Alcock, *Cat. Indian Decap. Crust.*, III, i, p. 21, pl. iii, figs. 9, *9a-d*.
1911. *Penaeopsis* sp., de Man, *Decap. 'Siboga' Exped.*, I, *Penaeidae*, p. 60 and (1913) pl. vi, fig. 17.

With respect to this species Alcock notes that in the vast majority of the females that he examined the fifth legs are reduced to a pair of horn-capped stumps. *P. dobsoni* is very abundant in the Chilka Lake, but in every female obtained the last legs are of normal length. It appears to me highly probable, as has already been suggested by Nobili, that the degeneration of these limbs is in some way connected with reproduction and, if this should prove to be the case, the condition of the Chilka

specimens lends support to the view, based on other evidence, that this species at any rate does not breed in the lake.

In the larger males the great barbed spine at the base of the third legs is well developed.

It is only in very large individuals that the rostrum has the comparatively straight dorsal outline shown in Alcock's figure. In the Chilka specimens, which do not exceed 75 mm. in length, there is a well elevated basal crest reaching from the posterior spine of the dorsal series to a point opposite the extremity of the eyes.

There can, I think, be no doubt that the specimen from Makassar recorded by de Man as '*Penaeopsis* sp.' is to be referred to this species. The figure of the thelycum is an exact representation of that of *P. dobsoni*; it is indeed more exact than the figure in Alcock's memoir, the latter suggesting a slight asymmetry which has no actual existence.

In life *P. dobsoni* is semitransparent; the pigment spots scattered on the carapace and abdomen are for the most part red, but tend to a browner shade on the rostrum and to a greenish tone on the posterior edges of each of the abdominal pleura. The antennules, antennae and antennal scales are dotted with red. There is a double row of reddish spots on the telson, the margins being greenish. Both uropods are red at the tip, the exopod being also bordered with red externally.

Like *P. monoceros*, this species is abundant in all parts of the Chilka Lake at all seasons of the year. It is particularly common in the main area on a muddy bottom. It appears to have a more restricted distribution than other species and has been recorded from both sides of the Indian Peninsula and from Makassar.

Family SERGESTIDAE.

Subfamily *LUCIFERINAE*.

Genus LUCIFER, Vaughan Thompson.

In giving an account of certain pelagic Decapoda collected by Mr. J. Stanley Gardiner[1], I expressed the opinion that Milne-Edwards' species, *L. reynaudi* and *L. typus*[2], could not be recognised with any certainty from the original descriptions and that Dana's work, published in 1852[3], must form the basis of our classification. So far as Milne-Edwards' *L. reynaudi* is concerned, this view had already been adopted by Faxon in 1895.[4]

Owing to lack of material for comparison, my account of the species represented in Mr. Gardiner's collection contains one serious misstatement. The specimens referred to Dana's *L. reynaudi* were said to be specifically distinct from others, obtained on the Ceylon coast, that I identified as *L. typus*, *auct.* Examination of

[1] Kemp, *Trans. Linn. Soc., Zool.* (2), XVI, p. 57 (1913).

[2] Milne-Edwards, *Hist. nat. Crust.*, II p. 469 (1837).

[3] Dana, *U.S. Explor. Exped., Crust.* I, p. 668 (1852).

[4] Faxon, *Mem. Mus. Comp. Zool., Harvard*, XVIII, p. 214 (1895).

further material from Indian waters has, however, convinced me that the characters on which I relied for the separation of the two forms are inconstant.[1] *L. typus, auct.* is therefore, as Ortmann pointed out in 1893[2], synonymous with Dana's *L. reynaudi* and, in view of the uncertainty that exists regarding the correct application of the former name, the species should, in my opinion, be known as *L. reynaudi* (Milne-Edwards) Dana.[3]

Three species of *Lucifer* are to be found in the Bay of Bengal. Specimens in the Indian Museum, collected for the most part by the R.I.M.S. 'Investigator,' are from the following localities:—

Lucifer acestra, Dana (= *L. reynaudi*, Bate[4] and Ortmann[5]).

Lat. 10°15′ N., long. 90°15′ E.; about 1800 fms. Mid-water net, 375 fms. to surface.
Lat. 9°8′ N., long. 87°25′ E.; $\frac{?}{1000}$ fms. Mid-water net, 475 fms. to surface.

Lucifer reynaudi (Milne-Edwards) Dana (= *L. typus*, Bate[6] and Ortmann[6]).

Lat. 10°48′ N., long. 75°, 1′ E.; 500 fms. Surface net.
Lat. 12°40′ N., long. 98°26′ 30″ E.; 10 fms. Surface net.
Lat 11°57′30″ N., long. 98°19′ E.; 7 fms. Surface net.
Mergui Archipelago.
Off Ceylon coast.

Lucifer hanseni, Nobili.

Lat. 10°48′ N., long. 75° 1′ E.; 500 fms. Surface net.
Lat. 12°55′15″ N., long. 98°27′ E.; 12 fms. Surface net.
Lat. 12°40′ N., long. 98°26′30″ E.; 10 fms. Surface net.
Lat. 11°57′30″ N., long. 98°19′ E.; 7 fms. Surface net.
Lat. 11°58′20′ N., long. 98°18′15″ E.; 8 fms. Surface net.
Mergui Archipelago.
E. of Diamond I., mouth of Bassein R., Burma.

L. reynaudi and *L. hanseni* were frequently found in the same haul.

The only species of *Lucifer* obtained in the Chilka Lake is *L. hanseni*, which

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[1] As regards the differential characters mentioned in my previous paper (*loc. cit.*, 1913, p. 60), I find on further examination that the pair of fine spinules that occur in the male behind the posterior tooth on the ventral margin of the last abdominal somite are sometimes present, sometimes rudimentary and sometimes entirely absent. The difference observed in the proportions of the outer uropod is apparently due to age, the segment being proportionately narrower in young individuals.

[2] Ortmann, *Decap. Schizop. Plankton-Exped.*, p. 40 (1893).

[3] Since this paper went to press I have received a copy of Mr. Borradaile's recent note on the species of *Lucifer* [*Ann. Mag. Nat. Hist.* (8), XVI, p. 226 (1915)]. Mr. Borradaile, relying on the accuracy of figures published by a number of authors (a procedure that, in the case of the 'Challenger' Report at least, seems decidedly perilous), has introduced no less than six new species, of several of which he has apparently not seen specimens. Nobili's *Lucifer hanseni*, doubtless owing to an oversight, is omitted. I regret that in the account here given I have not dealt more fully with the individual variation of *L. hanseni* and with the differences which exist between young and old specimens. Such variation is probably considerable throughout the genus (see footnote above) and, until it has been studied in detail, the multiplication of specific names by such methods as Mr. Borradaile has adopted is to be deprecated.

[4] Bate, *Rep. 'Challenger' Macrura*, p. 466, pl. lxxxiv (1888).

[5] Ortmann, *loc. cit.*, p. 40.

[6] Bate, *loc. cit.*, p. 464, pl. lxxxiii (1888).

occurs abundantly in fresh and brackish water and is evidently able to tolerate great changes in salinity.

Lucifer hanseni, Nobili.

1905. *Lucifer hanseni*, Nobili, *Bull. Mus. d'Hist. nat., Paris*, p. 394.

1906. *Lucifer hanseni*, Nobili, *Ann. Sci. nat., Zool.*, (9), IV, p. 25, pl. ii, fig. 1, and text-figs. 3*b*, p. 27.

The specimens from the Chilka Lake, along with others obtained by the 'Investigator' in various parts of the Bay of Bengal, undoubtedly belong to this species. *L. hanseni*, as Nobili has remarked, is closely allied to Dana's *L. reynaudi* (=*L. typus* of Nobili and other authors); but his table for their separation is in some respects misleading. Judging from the material in the Indian Museum the principal distinctions between the two forms are as follows:—

L. hanseni, Nobili.	*L. reynaudi* (Milne-Edwards) Dana. (=*L. typus*, Bate, Ortmann, Nobili.)
'Neck' shorter; in female from $2\frac{1}{5}$ to $2\frac{1}{4}$ times, in male twice or less than twice the length of remainder of carapace.	'Neck' longer; in female from $2\frac{1}{2}$ to $2\frac{3}{4}$ times, in male about $2\frac{1}{3}$ times the length of remainder of carapace.
Eyes not quite reaching distal end of basal antennular segment.	Eyes reaching to or beyond distal end of basal antennular segment.
Abdominal segments with a spine above base of pleopods in very large males only.	Abdominal segments with a strong spine above base of pleopods in both sexes.
Sixth abdominal somite from 2 to $2\frac{1}{3}$ times as long as deep, without or with only a very small postero-dorsal spine (text-figs. 37*a*, *b*).	Sixth abdominal segment from $2\frac{1}{2}$ to 3 times as long as deep, with a more conspicuous postero-dorsal spine (text-figs. 38*a*, *b*).
Anterior spine on ventral margin of sixth abdominal somite of male situated much nearer to posterior spine than to anterior margin of segment; no spinules behind posterior spine. The same margin in female unarmed, rarely with a pair of fine spinules placed posteriorly (text-figs. 37*a*, *b*).	Anterior spine on ventral margin of sixth abdominal somite of male situated almost midway between posterior spine and anterior margin of segment; a pair of fine spinules frequently present behind posterior spine. The same margin in female always provided with a pair of fine spinules placed posteriorly (text-figs. 38*a*, *b*).
Spine at distal end of outer uropod not nearly reaching to distal end of segment (text-figs. 37 *c*, *d*).	Spine at distal end of outer uropod reaching almost to, or in young males beyond, distal end of segment (text-figs. 38*c*, *d*).

In addition *L. hanseni* is decidedly stouter in build and the antennal scale is broader (about 9 times as long as broad in *L. hanseni* as compared with 11 times as long as broad in *L. reynaudi*). The 'phymocerite' at the base of the antennae is certainly present in some specimens of *L. hanseni*; but in others it appears to be missing.

In practice the most useful of the characters noted above is the difference in the form of the outer uropod. The position of the spine on the external margin is a valuable aid to identification in the species of *Lucifer*; in *L. acestra* it is different from both the species mentioned above, extending in both adults and young far beyond the apex of the lamella.

Lucifer hanseni occurred in shoals in the Chilka Lake and was abundant in the main area at all times of the year, existing in water of specific gravity varying from 1·000 to 1·0150. In the outer channel it was common in September in fresh water; but was extremely scarce in March when the water was as salt as the Bay of Bengal near the lake (sp. gr. 1·0265). If the only data available were those obtained in the Chilka Lake, one would suspect that the species preferred a low salinity and that it was only by chance that it came in contact with sea-water. But the species, as will be seen from the records on p. 323, is common in the Bay of Bengal and was on one occasion found in nets fished in mid-water over a sounding of 500 fathoms. I am

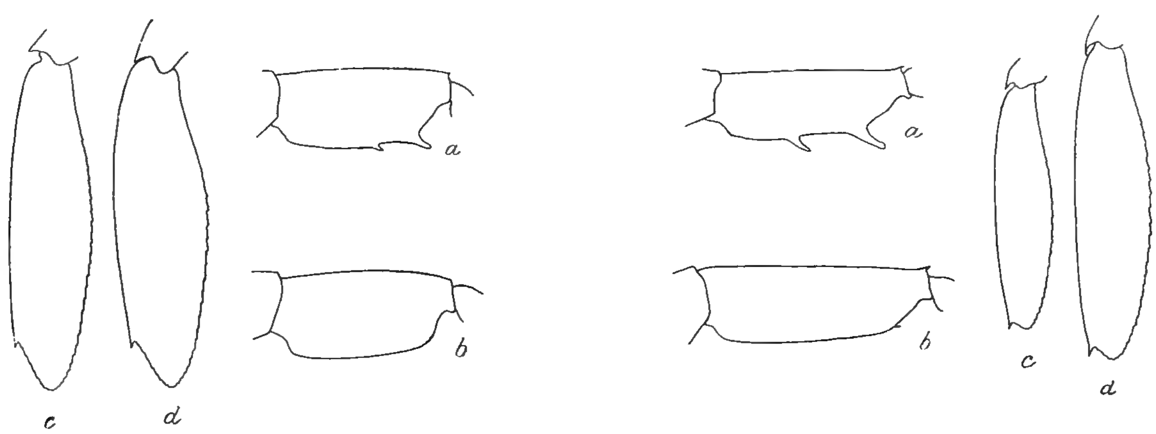

FIG. 37.—*Lucifer hanseni*, Nobili. FIG. 38.—*Lucifer reynaudii*, M.-Ewd. (Dana).

a. Last abdominal somite of male, in lateral view,
b. *do.* of female, in lateral view.
c. Outer uropod of male.
d. Outer uropod of female.

unable to offer any explanation of the scarcity of the species in the outer channel in March.

Young post-larval specimens were found on a number of occasions in the fresh-water season, but I am not convinced that the species actually breeds in the lake; the young individuals obtained may have grown from larvae brought into the lake from the sea some months earlier. Specimens from the lake are on the whole decidedly smaller than those obtained in the Bay of Bengal; the largest individuals from the Chilka Lake scarcely reach 8 mm. in length, whereas those from the 'Investigator' collections frequently exceed 11 mm.

Apart from the specimens from the Chilka Lake and from those recorded on p. 323, *Lucifer hanseni* is known only from the Red Sea.

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FAUNA OF THE CHILKA LAKE

MOLLUSCA GASTROPODA AND LAMELLIBRANCHIATA.

By N. ANNANDALE, *D.Sc., and* STANLEY KEMP, *B.A.*

(Plates XIV—XVI.)

WITH AN ACCOUNT OF

THE ANATOMY OF THE COMMON *SOLEN*.

By EKENDRANATH GHOSH, *M.Sc.*

(With 3 text-figures.)

CONTENTS.

MOLLUSCA GASTROPODA AND LAMELLIBRANCHIATA.

By N. ANNANDALE *and* STANLEY KEMP.

INTRODUCTION.

Our object in preparing this report has been, not to criticise genera and species from a taxonomic point of view, but to discuss in relation to their biological environment the distribution of the forms that occur in the Chilka Lake, and thus to bring the Mollusca, so far as possible, into line with the other groups dealt with in this volume. So far as nomenclature is concerned, we have in most cases followed that adopted by Mr. H. B. Preston in the series of papers contributed by him to the *Records of the Indian Museum* between 1907 and 1916. Full references to these and to other papers dealing with what von Martens calls the "sub-marine" molluscs of the Indian coasts are given in the bibliography on p. 364.

In the collections from the Chilka Lake that we have sent to Mr. Preston he recognizes no less than 34 species of Gastropods and 45 of Lamellibranchs. Of these he has described 42 species as new. We do not disparage his work, undertaken as it has been with a purely conchological aim, in saying that we expect that many of these species will ultimately prove to be no more than dwarfed or distorted phases of molluscs that occur elsewhere in more normal conditions. Cooke has pointed out with admirable clearness in his volume in the *Cambridge Natural History* (vol. III, p. 82) that a naturalist's concept of species and varieties in Mollusca must be profoundly modified by his point of view. Our point of view is not Mr. Preston's, but unfortunately we lack his special knowledge. We have therefore accepted his conclusions in so far as they do not run counter to the facts we have observed in the field.

In our Introduction to this volume we have dealt at length with the physical conditions of life in the different parts of the lake-system and in particular with the periodic changes in the salinity of the water. It will be as well, however, to recapitulate briefly our statements on these points in so far as they influence the distribution of the Mollusca.

The whole of the lake-system is very shallow, rarely more than 2 fathoms in

depth, and the variations of level that occur at different seasons, though relatively great (about 5 or 6 ft.), are not sufficient to have any appreciable direct effect on the fauna. The bottom of the main area of the lake is covered with soft mud, which probably overlies a deep layer of clean sea-sand, while along the outer shore of this area and round some of the lower islands, sand and mud are mixed. At most places at which this occurs the water becomes excessively shallow in the dry season and is so heated by the sun that conditions are inimical to most forms of animal life; but the admixture is a marked feature of the bottom round the island of Nalbano and a belt of gritty mud extends in fairly deep water out into the channel by means of which the lake is connected with the sea. The outer part of this channel, near the sea-mouth, is scoured by currents at certain seasons and its bottom consists of clean sand. At several points along the inner shore of the main area and on some of the islands there are rocks, partially or entirely submerged in summer and autumn, but in spring exposed and dry owing to the sinking of the water-level. In sheltered spots, where the water near the shore is relatively deep, dense thickets of weed grow up in autumn, dying out almost completely in the rainy season. They consist for the most part of a species of *Potamogeton* that sometimes attains a height of at least five feet in order to flower on the surface. A fine-branched alga also forms somewhat lower thickets at a few places in both parts of the lake-system.

For the greater part of the year the whole of the main area is filled with water that may be called brackish, having a specific gravity (corrected) that reaches a maximum of 1·0150. At this period there is an abrupt change in salinity at the point where the outer channel opens into the main area, the water in the former being, at the height of the season, as salt, or very nearly as salt as that of the Bay of Bengal outside the sea-mouth (sp. gr. 1·02650). Between August and October floods of fresh water pour in from the rivers at the north, driving before them the salter water, until the northern part of the main area and the whole of the outer channel become entirely fresh. In a comparatively small area at the southern end of the lake into which no rivers open, the floods have less effect and the water remains brackish throughout the year, the specific gravity varying from 1·003 to 1·015. The northern boundary of this area is situated close to the island of Kalidai, which forms a land-mark in the distribution of species.

The specific gravities recorded in the table on pp. 332, 333 represent not the full range of salinity in which the species may occur, but merely that in which we found living specimens in the Chilka Lake.

In the collection of the Indian Museum there are specimens of some 37 named species of Gastropods and 47 of Lamellibranchs from the lake. Certain shells that we believe to have been introduced by man or other agents may be dismissed very briefly. We have no reason to include these species among the living fauna, for the Gastropods are merely represented by dead shells, most of which were occupied by hermit-crabs, while of the Lamellibranchs only single valves were obtained, in circumstances which suggested that they had been brought from the coast by man. These introduced shells are:—

GASTROPODA.

Nassidae.
Bullia vittata, Linn.

Strombidae.
Strombus isabella, Lk.

Viviparidae.
Vivipara bengalensis, Lk.

Ampullariidae.
Ampullaria globosa, Swains.

Naticidae.
Natica marochiensis, Gmel.
,, *maculosa*, Lam.

LAMELLIBRANCHIATA.

Veneridae.
Meretrix morphina, Lk.
Meröe scripta, Gray.
,, *chilkaënsis*, Preston.
,, *satparaënsis*, Preston.

Donacidae.
Donax pulchella, Hanley.

Tellinidae.
Tellina barhampurensis, Preston.

Dead shells of the freshwater Gastropods that live in pools and rice-fields are common on the shores of the lake and are occasionally carried into it by winds, by birds and by hermit-crabs of the semi-terrestrial genus *Coenobita*, which also bring marine shells, such as those of *Natica* and *Strombus*, across the sand-hills from the sea. Marine shells, especially those of Lamellibranchs, are commonly collected on the sea-shore by Uriya fishermen and used for the manufacture of lime, lime from this source being highly esteemed as an ingredient in *pân*. Such shells are often dropped in the neighbourhood of villages. They must be carefully distinguished from the sub-fossil shells found at certain places (see p. 338).

The living Mollusca of the lake, omitting Nudibranchs and introduced shells, are listed on pp. 332, 333 and[1] comprise, so far as our knowledge goes, 73 species, 31 of Gastropods and 42 of Lamellibranchs. The Gastropods are distributed among 14 families and 19 genera, the Lamellibranchs among 20 families and 25 genera. No less than 28 species, with one genus (*Chilkaïa*)—that is to say, about 38 % of the total number—appear at present to be endemic in the lake-system.

The great majority of the genera are certainly of marine origin, the only exceptions being *Potamides*, *Chilkaïa* (?), *Hydrobia* and *Stenothyra*. *Potamides* is essentially an estuarine genus and the two species by which it is represented occur commonly in brackish water all over the Oriental region, in Australia and in Japan. The genus *Chilkaïa*, as at present known, is represented by a single minute species belonging to a family the other members of which are marine. On the other hand *Hydrobia* and *Stenothyra* belong to a family of which most of the species inhabit fresh water, but many make their way into estuarine tracts and are found only in brackish water. This is the case with most of the Indian species. More than half of those of *Stenothyra* known from India have been found in the Chilka Lake.

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[1] The figures in the second column of this table indicate the specific gravity of the water in which living specimens were obtained. Species which, so far as is yet known, are endemic in the lake-system are distinguished by an asterisk.

	Specific gravity of water.	Distribution in Lake. Main area.	Distribution in Lake. Outer channel.	Further Distribution.
Gastropoda.				
TORNATINIDAE.				
Tornatina estriata, Preston	1·000—1·0265	X	X	Cochin backwaters.
BULLIDAE.				
Bulla (*Haminea*) *crocata*, Pease	1·000 [1]—?	..	X	Indo-pacific.
NASSIDAE.				
Nassa sistroidea, G. & H. Nevill	1·000—1·0265	..	X	Andamans.
,, *labecula*, A. Ads.	1·000—1·0265	X	X	Philippines.
,, *marrattii*, Smith	?	..	X	Mekran coast to Solomon Is.
,, *denegabilis*, Preston	1·000—1·0265	X	X	Cochin and Madras backwaters; Gangetic delta.
,, *orissaënsis*, Preston	1·000—1·0265	X	X	Madras backwaters; Gangetic delta.
MURICIDAE.				
Thais carinifera (Lam.)	1·005—1·0265	X	X	E. Africa to Australia.
CERITHIIDAE.				
Potamides (*Tympanotonos*) *fluviatilis*, Pot. & Mich.	1·000—1·0265	X	X	India to Australia and Japan.
,, (*Telescopium*) *fuscum*, Schum.	1·0265	..	X	,, ,, ,,
TURRITELLIDAE.				
Vanesia rambhaënsis (Preston)	1·000—1·015	X	X	Cochin backwaters
FOSSARIDAE.				
Chilkaïa imitatrix,* Preston	1·000—?	..	X	
LITIOPIDAE.				
Litiopa (*Alaba*) *kempi*,* Preston	1·000—1·015	X	X	
,, ,, *copiosa*,* Preston	1·000—1·0265	X	X	
HYDROBIIDAE.				
Hydrobia (*Belgrandia*) *myliacea*, Nevill	?	?	?	Gangetic delta.
Stenothyra blanfordiana, Nevill	?	?	?	Gangetic delta; Madras.
,, *minima* (Sowerby)	1·000—1·0265	X	X	Western India; Ceylon.
,, *chilkaënsis*,* Preston	1·000—1·0265	X	X	
,, *orissaënsis*,* Preston	1·000—1·0265	X	X	
,, *trigona*,* Preston	1·000—1·015	X	X	
,, *obesula*,* Preston	1·000—?	..	X	
SCALARIIDAE.				
Epitonium hamatulae,* Preston	?	..	X	
PYRAMIDELLIDAE.				
Pyrgulina humilis (Preston)	1·000—1·0265	X	X	Cochin backwaters; Ceylon.
Chrysallida (*Mormula*) *ecclesia*,* Preston	?—1·015	X	..	
,, ,, *nadiensis*,* Preston	1·000—?	..	X	
Odostomia chilkaënsis,* Preston	1·0265	..	X	
NERITIDAE.				
Neritina (*Theodoxus*) *souverbiana*, Montr.	1·000—1·0265	..	X	China Sea; New Caledonia.
CYCLOSTREMATIDAE.				
Cyclostrema (*Tubiola*) *innocens*,* Preston	?	..	X	
Tinostoma variegatum,* Preston	1·0265	..	X	
TROCHIDAE.				
Umbonium vestiarium (Linn.)	1·0265	..	X	Warm and tropical seas.
Solariella satparaënsis,* Preston	1·000—1·0265	..	X	
Lamellibranchiata.				
OSTREIDAE.				
Ostrea virginiana, Gmel.	1·000—1·0265	X	X	W. coast of N. America; ? all tropical seas.
,, *cucullata*, Born.	1·000—1·0265	..	X	Indo-pacific.
,, *lentiginosa*, Sowerby	1·0265	..	X	?

[1] A single dwarfed specimen.

SPECIES.

	Specific gravity of water.	Distribution in lake. Main area.	Distribution in lake. Outer channel.	Further Distribution.
MYTILIDAE.				
Mytilus smaragdinus, Chemn.	?	..	X	Arabian Sea to Hongkong; ? N. Zealand.
Modiola undulata (Dunker)	1·000—1·0265	X	X	Moluccas; Gangetic delta.
,, *striatula*, Hanley	1·000—1·0265	X	X	Arabian Sea to Philippines.
ARCIDAE.				
Arca (*Anadara*) *granosa* (Linn.) ..	1·003—1·015	X	?	Arabian Sea to Japan and Australia.
,, (*Fossularca*) *lactea* (Linn.) ..	1·0265	..	X	E. Atlantic to Burma; ? Philippines.
ERYCINIDAE.				
Kellya chilkaënsis,* Preston	1·000—1·0265	X	X	
,, *mahosaënsis*,* Preston	1·007	..	X	
GALEOMMIDAE.				
Scintilla chilkaënsis,* Preston	1·000—?	..	X	
CARDIIDAE.				
Cardium (*Fulvia*) *rugatum*, Gronov. ..	1·0265	..	X	Bay of Bengal to New Britain.
VENERIDAE.				
Meretrix meretrix (Lam.)	1·000 ?—1·0265	..	X	
,, *casta*, Chemn.	1·000 ?—1·0265	..	X	Indian Seas; Ceylon; Singapore.
,, *ovum*, Hanley	1·000 ?—1·0265	..	X	Indian Seas.
Tivela dillwyni (Deshayes)	1·000—?	..	X	
Tapes pinguis, Chemn.	1·000 ?—1·0265	..	X	Eastern Indian Ocean.
,, *ceylonensis*, Sowerby	1·000 ?—1·0265	..	X	Indian Seas; Ceylon.
Clementia annandalei, Preston	1·000—1·0265	X	X	Gangetic delta.
PETRICOLIDAE.				
Petricola esculpturata,* Preston ..	1·000—1·0265	..	X	
UNGULINIDAE.				
Diplodonta satparaënsis,* Preston ..	1·009—1·0265	X	X	
,, *barhampurensis*,* Preston ..	?	..	X	
,, (*Felania*) *annandalei*,* Preston	1·009—1·0265	X	X	
,, ,, *ovalis*,* Preston ..	1·0265	..	X	
,, ,, *chilkaënsis*,* Preston	1·0265	..	X	
PSAMMOBIIDAE.				
Psammobia mahosaënsis,* Preston ..	1·000—1·0265	X	X	
SOLENIDAE.				
Solen ? fonesi, Dunker	1·000—1·0265	X	X	Cochin backwaters; Philippines; Cebu.
,, *annandalei*,* Preston	?	X	X	
,, *kempi*,* Preston	?—1·0265	X	X	
MACTRIDAE.				
Standella annandalei,* Preston.. ..	1·008—? 1·0265	X	X	
MYIDAE.				
Corbula chilkaënsis,* Preston	*ca.* 1·010	X	..	
PHOLADIDAE.				
Martesia striata (Linn.)	?	?	?	Cosmopolitan.
TEREDINIDAE.				
Xylotrya stutchburyi, Sowerby	1·000—1·0265	..	X	Malay Archipelago.
TELLINIDAE.				
Tellina chilkaënsis,* Preston	?	..	X	
,, *confusa*,* Preston	?	?	?	
SCROBICULARIIDAE.				
Theora opalina (Hinds)	1·000—1·0265	X	X	Indian coasts to Philippines.
Cumingia hinduorum,* Preston ..	1·000—1·0265	X	X	
CUSPIDARIIDAE.				
Cuspidaria annandalei, Preston ..	1·000—1·0265	X	X	Madras and Cochin backwaters; Gangetic delta.
LYONSIIDAE.				
Lyonsia samal-insulae,* Preston ..	1·000—1·0265	X	X	
ANATINIDAE.				
Anatina granulosa,* Preston	?	?	?	
,, *barkudaensis*,* Preston ..	1·000 ?—1·0265	X	X	
,, *barkulensis*,* Preston	1·000—1·010	X	X	

Several of the genera represented in the lake fauna, though essentially marine, include species characteristic of an estuarine environment. As examples of these we may mention *Nassa* and *Thais* among the Gastropods and, among the Lamellibranchs, *Modiola*, *Arca*, *Meretrix*, *Corbula*, *Martesia*, *Clementia* and *Theora*. The species of Pholadidae, Teredinidae, Arcidae and Solenidae are, however, quite distinct from those that have established themselves in the Ganges and other Indian rivers.

GEOGRAPHICAL DISTRIBUTION.

With the exception of *Chilkaïa*, all the genera that comprise the molluscan fauna of the Chilka Lake have a very wide geographical distribution, whereas, as we have already pointed out, more than one third of the species at present appear to be endemic. Apart from apparently endemic species the Mollusca of the lake fall, with one or two possible exceptions, into two categories, (*a*) those that are found only in other localities of a similar nature on the Indian coasts and (*b*) those of wide distribution. The number of the former is comparatively small, but with further exploration it is probable that many of the apparently endemic species will be transferred to this category. The following forms are known to occur both in the Chilka Lake and in estuarine tracts in other parts of India, but have not been found elsewhere:—

GASTROPODA.

Tornatina estriata.
Vanesia rambhaënsis.
Nassa denegabilis.
,, *orissaënsis.*
Hydrobia (*Belgrandia*) *myliacea.*
Stenothyra blanfordiana.

LAMELLIBRANCHIATA.

Clementia annandalei.
Cuspidaria annandalei.

A considerable amount of work has been done by Nevill, W. T. Blanford, Benson, Stoliczka, von Martens and Preston on the aquatic shells of estuarine tracts in India and the Malay Archipelago; but (except in the case of the last author) most of their papers refer exclusively to species found at the edges of creeks and backwaters or in small pools of brackish water. This is probably one of the reasons why our collection from the Chilka Lake differs very greatly from those previously described from similar localities, a very large proportion of the species having been obtained by dredging. A real difference, namely the scarcity in the lake of certain thick-shelled amphibious forms, such as *Neritina*, *Littorina* and *Pythia*, is probably explained by the absence of mangroves and semi-aquatic palms to the stems of which such species frequently attach themselves. It is less easy to explain the entire absence of the almost terrestrial mud-loving genus *Onchidium* and the absence or scarcity of the aquatic genera *Iravadia* and *Corbula*, which are remarkably abundant in the Gangetic delta. The occurrence of *Cyclostrema* is, however, interesting, as we believe that Nevill's "*Valvata? microscopica*," a species very abundant at Port Canning, also belongs to this genus.

Some years ago a considerable collection of shells was made in shallow water off

the coast of Orissa by the S.S. 'Golden Crown,' but not a single species is common to this collection and to our own, while most of the genera are different,—a fact due perhaps in the main to the nature of the bottom on which the two collections were obtained.[1] So far as we have been able to discover, the molluscan fauna of the Chilka Lake, at any rate in the matter of Lamellibranch genera, is nearer to that collected, in shallow water and mainly on muddy ground, by the Danish Expedition to Siam[2] than to any other on which a comprehensive report has yet appeared. Eighteen Lamellibranch subgenera and genera are common to the two collections, representing two thirds of those found in the lake.

BIOLOGICAL DISTRIBUTION.

Less than 50 % of the living Mollusca of the lake are found in the main area, and even this percentage is somewhat reduced if we omit the island of Nalbano. With two exceptions, *viz. Corbula chilkaënsis* and *Chrysallida ecclesia*, each represented by a single specimen, all species found in the main area were also found in the outer channel, but the great majority did not occur on the clean sandy bottom of the seaward part of the latter. By far the richest tract in the whole lake-system is the southern end of the outer channel between Barhampur I. and Satpara Point (see map, Pl. II of this volume).

The following species have a great numerical preponderance throughout the main area, except where the water is excessively shallow:—

GASTROPODA.	LAMELLIBRANCHIATA.
Tornatina estriata.	*Modiola undulata.*
Nassa denegabilis.	*Clementia annandalei.*
,, *orissaënsis.*	*Solen ? fonesi.*
Stenothyra spp.	*Theora opalina.*

With the exception of the species of *Nassa* and *Stenothyra*, all of these are much less abundant in the outer channel. In the channel the following species may perhaps be regarded as predominant:—

GASTROPODA.	LAMELLIBRANCHIATA.
Nassa labecula.	*Meretrix casta.*
Potamides fluviatilis.	,, *ovum*
Litiopa copiosa.	*Tapes pinguis.*
Pyrgulina humilis.	,, *ceylonensis.*

In this part of the lake it is much more difficult to select predominant species than in the other, for a large number of forms are represented by considerable numbers of individuals, whereas in the main area most of the species are either very rare or else extremely abundant.

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[1] Jenkins, *Rec. Ind. Mus.*, VII, p. 51 (1912).

[2] Lynge, *Danske Vid. Selsk. Skrift.* (7) Nat. og. Math., V, pp. 100-299 (1909).

The chief reasons for the difference between the molluscan fauna of the two regions appear to be two,—differences in salinity and differences in the nature of the bottom, the latter factor being perhaps more important in the case of Mollusca than in that of some other groups.

Apart from these distinctions between the two regions, there are other divisions in the fauna dependent on other causes: certain species are abundant in restricted localities. *Potamides fluviatilis*, for example, is extremely common in very shallow water on all ground in which the mud is mixed with sand, being apparently able to endure a high temperature fatal to other species, but avoiding soft mud. The same kind of bottom is also the only one that attracts the species of *Lyonsia* and *Anatina*, but they are burrowing forms not so easily observed.

The number of rock-haunting molluscs is very small; indeed, only two species, *Modiola striatula* and *Thais carinifera*, can be assigned definitely to this category. Both of these are abundant, but their distribution in the main area of the lake is not the same; for while the mussel is found in large numbers on all rocks that are submerged for more than a few months in the year, the *Thais* is restricted to those south of Kalidai, being found only in water the specific gravity of which never falls below 1·003. This species is also found on the oyster-beds at Manikpatna in salt water; its distribution in the lake evidently depends not only on salinity, but to some extent on the presence of mussels or other thin-shelled molluscs on which it preys.

The oysters that occur in the Chilka Lake belong to at least three species, but only one, *Ostrea virginiana*, is at all common Oyster-beds are found only in the neighbourhood of Manikpatna. At this place several small sandy islands are so arranged as to form a bay sheltered from currents that would prevent the deposition of spat, while the fact that the bay is situated at no great distance from the sea-mouth is of importance, both because the greater part of the silt from the flood-waters has already settled before the floods reach it, and because it obtains immediate benefit from the irruption of sea-water that occurs when they subside.

In March we occasionally found single living individuals of *O. virginiana* attached to rocks in the neighbourhood of Patsahanipur; in some of them the shell was as much as 3 cms. in diameter. Later in the year apparently fresh but empty shells of a similar size were noted in the same place. We believe that this indicates that a certain number of larvae make their way into the main area of the lake, on the rocks of which, as we will show later, the oyster was once abundant. They are able to settle down and to grow considerably, but are ultimately killed by the summer floods. If this is so, the rate of growth must be very rapid, but the Uriya fishermen state that when the oyster-beds at Manikpatna are overwhelmed with sand, as sometimes occurs in the flood-season, they are entirely renovated in a single year. The bulk of the beds are formed of living and dead shells of *O. virginiana*, to which a few individuals of *O. cucullata* and *O. lentiginosa*, with large numbers of *Modiola striatula*, attach themselves, while *Petricola esculpturata* esconces itself in cavities between them. So far as we were able to observe, the last-named species was entirely free from the necessity of constructing borings of its own.

Two species of molluscs were found only in or on wooden posts set up to mark the fairway in the outer channel near Satpara. These were the ship-worm *Xylotrya stutchburyi* and an oyster (*Ostrea* sp.) of which a few large individuals were obtained but have unfortunately been mislaid.

The periodic growth and decay of the thickets of weed to which we have alluded above is an important factor in the distribution of the Lamellibranchs *Modiola undulata* and *Cuspidaria annandalei*. The former is known to breed in the lake at all seasons and is found on filamentous algae growing on stones, but by far the greater number of the individuals observed were attached to thicket-forming weeds. Almost as soon as these weeds begin to grow up they are covered with young mussels, which increase in size rapidly and evidently become mature before the plant dies down. The same fact was noted to a less extent in the case of *Cuspidaria*. It is of importance to the fisheries of the lake, in that several of the more abundant edible species of fish haunt the thickets and devour weeds and molluscs together.

Several Gastropods also frequent weeds, notably the species of *Stenothyra*, *Litiopa*, *Pyrgulina* and *Chrysallida*; but these are also found in large numbers among algae of less luxuriant growth and do not form so characteristic a feature of the thickets. *Nassa denegabilis* and *N. orissaënsis* apparently crawl indifferently among weeds or on bare mud.

The great majority of the Mollusca found in the lake inhabit it throughout the year; but it was observed in the case of several of the commonest species, *e.g. Tornatina estriata*, *Clementia annandalei* and *Theora opalina*, that a very large number of individuals died in the latter part of the freshwater season—a fact of particular interest in view of the marine origin of the fauna. It would seem that in the Mollusca, as also in other groups, certain individuals are more tolerant of changes in salinity than the majority of their kind, and that the effect of fresh water on the organism, in at least some forms, is cumulative rather than suddenly fatal. The small Opisthobranch *Bulla crocata* affords interesting evidence. It was originally described from sheltered positions in the sea and is not uncommon, at any rate in certain seasons, in the Madras backwaters. The only living specimen we found in the Chilka Lake was taken in fresh water (in September, 1914), but was scarcely half the normal size, though the shell was fully formed. Full-sized specimens that had not long been dead were obtained, in the same month and in the same part of the lake, among decaying weed cast up on the shore. It would seem probable that the species makes its way into the lake either in the larval stage or before its growth is completed and that the majority of the individuals which have attained their full size in the salt-water season succumb to the freshwater floods. An unusually hardy individual, however, occasionally survives throughout the year, but is dwarfed by the unfavourable character of its environment.

A number of other species are represented in our collection only by fresh but empty shells, found in the outer channel in September in circumstances that did not suggest their having been introduced artificially. As examples we may mention *Cyclostrema* (*Tubiola*) *innocens* and *Epitonium hamatulae*. In several cases, notably

that of the species of *Diplodonta*, living molluscs were found in the salt-water season, but only dead shells in that of fresh water.

Several species, notably *Cardium* (*Fulvia*) *rugatum* and *Mytilus smaragdinus*, evidently make their way at a young stage from the sea into the outer channel, but are unable to survive until maturity; they must be classed merely as occasional visitors of no faunistic interest in so far as the lake-fauna is concerned.

Many species belonging to freshwater genera, such as *Ampullaria, Vivipara* and *Planorbis*, are very abundant in rice-fields and even in small pools of rain-water near the margin of the lake; but we did not observe a single instance in which molluscs of this kind made their way into the lake itself, even when its waters were quite fresh. This fact is particularly remarkable in the case of *Melania tuberculata*, which is common in pools of both fresh and brackish water near Rambha and occurs in great abundance in water of considerable salinity in the Gangetic delta.

SUBFOSSIL SHELLS.

The late Dr. W. T. Blanford drew attention in 1859 to the fact that there were large beds of subfossil estuarine molluscs in the neighbourhood of Rambha. The species best represented in these beds, as he noted, are *Arca granosa*, Linn., and *Meretrix casta*, Chemn. *Thais carinifera* is also fairly common. Worn shells of *A. granosa* and *M. casta* are also very abundant on the shore of Barkuda I.; the latter species, though common in the outer channel, is now extinct in the main area, in which *A. granosa* is very scarce.

Another species found in the main area in a subfossil condition is the common "window-pane oyster", *Placuna placenta* (Linn.), beds of which, of very limited extent, were proved to have existed near Samal I. and at other points. This mollusc no longer lives in any part of the lake, though it is collected for commercial purposes in lake Tamblegam (Tampalakaman), a smaller lagoon on the coast of Ceylon, the water of which probably also undergoes great seasonal changes in salinity.[1] A detailed comparison of the conditions in the two lagoons in this and in other respects would be of great interest.

We have already alluded to the young oysters occasionally found on rocks in the main area; at the southern end of the lake single valves, evidently long dead, were frequently observed, while at the edge of the water near Ganta Sila we found the remains of an oyster-bed. The species (*O. virginiana*) was the same as that now found living at Manikpatna, but the beds differed in that shells of the genus *Chama* were abundant on the oysters. On the rocks at the same place skeletons of solitary corals belonging to the family Turbinolidae were occasionally seen (pl. xiv, fig. 3). *Chama* was not found on the Manikpatna beds, but is usually associated with oysters taken in shallow water off the coast of Orissa, while the Turbinolidae are characteristically marine and are particularly abundant off the same coast.

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[1] Hornell, *Ceylon Marine Biol. Reps.*, I, p. 41 (1906). According to Mr. Hornell the specific gravity of the water of this lake in the dry season varies from 1·015 to 1·019 at temperatures from 86° to 90° F. No observations have been made as to the conditions in the wet season.

It is probable that these subfossil species do not all belong to the same period in the history of the lake, though all are undoubtedly recent. The oyster-bed at Ganta Sila (in the presence of *Chama*) and the corals on the rocks evidently date from a time when this part of the lake was in direct communication with the Bay of Bengal; Ganta Sila and the hills near it then forming an island or group of islands in the sea. On the other hand the beds of *Arca* and *Meretrix* at the head of Rambha Bay mark the position of a channel or creek of later date, probably containing brackish water and representing all that then remained of the sea-passage that once separated the islands from the mainland. The beds may possibly have been laid down when the lake-area, though closed to the south, still remained an open bay with a purely marine fauna; but doubt is cast on this view by the existence of precisely similar shells in a subfossil condition on the shores of Barkuda I.

The only case in which we have been able to observe a difference between subfossil and living shells is that of *Arca granosa*. The subfossil shells of this species exhibit considerable variety of form (some being much more nearly bilaterally symmetrical than others) and are never of more than moderate size, the largest having a breadth of 50 mm. The few living examples we obtained were much smaller, the greatest breadth being 26 mm. They differ somewhat in form from any of our subfossil examples in being relatively broader and less inflated (*cf.* figs. 3-6, pl. xvi). Von Neumayer has described a variety of this species under the name "*Arca granulosa* var. *minuta*",[1] from a point some distance up the Yang-tse-Kiang river. It was taken with shells of freshwater genera such as *Vivipara*, *Bythinia*, *Melania* and *Corbula*; the specimens were found in silt and were apparently in a subfossil condition.[2] Our own examples from the main area of the Chilka Lake bear a general resemblance to his figures, but are a little larger and more symmetrical. The variation in *A. granosa* may thus be compared with that recorded by Bateson in the case of *Cardium edule*[3]; but, except in the points noted, we are unable to correlate it definitely with changes in environment.

SPECIAL CHARACTERISTICS OF THE MOLLUSCAN FAUNA.

In the general facies of the molluscs of the lake the most noteworthy characters are small size, lack of bright pigment and thinness of shell.

Among the Gastropods the only shells that commonly attain a length of more than 1 cm. are *Nassa labecula*, *N. marrattii*, *Potamides fluviatilis*, *P. fuscum* and *Thais carinifera*; of these only three occur in the main area, the majority of the shells in this region being less than 5 mm. long. In the case of Lamellibranchs a few fairly

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[1] *Wiss. Ergebn. Reise Bêla Széchenyi in Ostasien*, 1877-80, II, p. 641, pl. i, fig. 4 (1898).

[2] In the markets of Shanghai, Soochow and the smaller towns in the same district a dwarfed form of *A. granosa* is commonly on sale in a living condition. It is said to come from near Ningpo. The shells are covered with fine mud and sometimes bear dead or living *Balani*. With them I found mixed, in some instances, shells of Cerithiidae and Nassidae of distinctly brackish-water facies. The largest *Arca* shells of this form are about 30 mm. broad and about 20 mm. high.—*N. A.*; *Soochow*: 7-xii-15.

[3] *Phil. Trans. Roy. Soc.*, CLXXX (B), p. 297 (1889).

large forms, such as the species of *Ostrea*, *Meretrix*, *Tapes* and *Standella*, occur in the outer channel and in some cases make their way in small numbers into the northern part of the main area. The only species of even moderate dimensions that occur in the southern part of this area are, however, the almost extinct *Arca granosa* and the species of *Modiola* and *Anatina*.

It is only in a few cases that it is possible to compare individuals from the lake with those from more favourable localities, but in those instances in which this can be done, as in *Modiola striatula*, *Arca granosa* and *Nassa orissaënsis*, a distinct dwarfing can be detected. In *Arca granosa* all individuals are affected in the same way, and the dwarfing may be due entirely to changes in salinity, while in *Modiola striatula* different individuals are influenced in different ways and other causes, such as confined position and periodic desiccation, seem sufficient to account for the results observed (see pp. 362, 363). We have provisionally accepted Mr. Preston's identification of the small *Solen* common in the lake on a muddy bottom as *S. jonesi*, Dunker. If this be correct, the race is evidently dwarfed, for shells of sexually mature individuals are always under 30 mm. in length, whereas specimens of nearly 6 cms. have been found in the sea. Shells from the lake are relatively much broader than any of those noticed by von Martens, who remarks that larger shells are proportionately narrower than smaller ones. *Nassa orissaënsis* is represented in backwaters near Madras and also in canals of brackish water in the Gangetic delta by a form (var. *ennurensis*, Preston) with a considerably larger and more deeply sculptured shell; but it is difficult to see in what respects the conditions in these localities are more favourable.

None of the shells from the lake, with the exception of those of *Modiola*, are brilliantly coloured and dense pigmentation is the exception rather than the rule. Its absence is particularly noteworthy in the Lamellibranchs, among which colourless forms such as the species of *Kellya*, *Clementia*, *Petricola*, *Diplodonta*, *Psammobia*, *Standella*, *Theora*, *Cumingia*, *Cuspidaria*, *Lyonsia* and *Anatina*, greatly predominate. Among the Gastropods the commonest colours are dull brown and dull green, as in *Vanesia*, *Litiopa*, *Nassa*, *Stenothyra* and *Potamides*. The number of colourless species is comparatively small, comprising those of *Tornatina*, *Pyrgulina* and *Chrysallida*. The only species in which well-defined and conspicuous markings occur on the shell[1] are *Neritina souverbiana*, *Tinostoma variegatum* and *Umbonium vestiarium*; even in these the markings are almost microscopic. The only mollusc in which the living tissues are brilliantly coloured is *Scintilla chilkaënsis*, in which the mantle is yellow and orange.

In the absence of bright colours the fauna resembles that of fresh water and differs from that of the coast immediately outside the lake, where brilliantly painted species such as *Siliqua radiata*, *Eburna* and *Sunetta scripta* are abundant. The complete lack of colour in many of the Lamellibranchs is doubtless correlated with their burrowing habits.

It is among the Lamellibranchs also that thinness of shell is most noteworthy.

[1] Young shells of *Meretrix ovum* are marked with radiating lines of conspicuous brown spots, but these practically disappear in adults.

Such forms as those of *Kellya*, *Scintilla*, *Diplodonta*, *Solen*, *Standella*, *Theora*, *Cumingia*, *Cuspidaria*, *Lyonsia* and *Anatina* are remarkable in this respect, while the shell of the *Clementia* is so fragile that we had great difficulty in preserving perfect specimens. Thick-shelled species such as those of *Arca*, *Meretrix* and *Tapes* are few and have almost completely disappeared from the main area. Except possibly in the case of *Modiola*, we have, however, no evidence that individuals from the lake have thinner shells than those of the same species living elsewhere. Among the Gastropods, *Thais* and *Potamides* are exceptional in the thickness of their shell; there is no form comparable in the opposite direction to *Clementia*.

The thinness of shell in the lake species can hardly be due to lack of dissolved calcareous matter, for considerable quantities of '*kankar*' (nodular concretions of carbonate of lime) are dug from the bed of the lake when the level of the water is low. In the case of many of the Lamellibranchs (*e.g.* *Clementia* and *Theora*) it is associated with life in peculiarly soft and adhesive mud, through which the animals progress with considerable rapidity. It is noteworthy, moreover, that all the thick-shelled burrowing Mollusca found in the lake inhabit sand or sandy mud and that there is no evidence that the shells of such forms are thinner than those found in pure salt water.

These facts are of some interest because instances are well known in the Baltic and elsewhere, in which the shells of marine species related to the Chilka forms become greatly attenuated in brackish water. Gibbons[1] has, however, pointed out that though this is the general rule, the shells of true brackish water species may tend to become thicker in correlation with decrease of salinity.

We have already alluded to the fact that, especially in the main area, a comparatively small number of species predominate greatly in respect to number of individuals. It is probable that if a census of the Mollusca of the main area could be taken, the great majority would fall into some eight or nine species and some half dozen genera. This feature is also characteristic of other groups of animals found in the lake and, indeed, generally of animals living in abnormal conditions.

LIST OF SPECIES.

Class GASTROPODA.

Order *OPISTHOBRANCHIATA*.

Family **Tornatinidae**.

Tornatina estriata, Preston, 1914, p. 303, figs. 7, 7*a*; 1915, p. 297; 1916, p. 27 (as *Retusa*); syn. *T. soror*, Preston, 1914, p. 303, figs. 8, 8*a*.

This is one of the commonest Gastropods on a muddy bottom in both sections of the lake-system. Shells from the outer channel tend to be a little larger than those from the main area and to have a less ovately cylindrical form. Mr. Preston separated the latter under the name *T. soror* in 1914, but has now found inter-

[1] Gibbons, *Quart. Journ. Conch.*, I, p. 339 (1878.)

mediate specimens in our collection and regards this name as a synonym. The species is found in a living condition at all seasons of the year, but at the end of the freshwater season dead shells are extremely abundant. *T. estriata* has also been found in backwaters on the west coast of India.

Family **Bullidae**.

Bulla (Haminea) crocata, Pease, *Proc. Zool. Soc. London*, 1860, p. 19.

This species, which is common among weeds in the backwaters near Madras, does not appear to have become thoroughly acclimatized in the Chilka Lake. Dead shells, some of which contained remains of the soft parts, were found among drift weed on the shore at Satpara in September, and a single small but apparently full-grown living individual was taken in the same month in Seruanaddi. A dead and much eroded shell was found on the shore of Barhampur I. in March.

Our largest shell is about 14 mm. long, but the one from Seruanaddi is less than 5 mm. long. We have discussed the significance of these facts on p. 337.

The species was described from the Sandwich Is., where it was found "usually on sand-flats, but occasionally on seaweed." It was noted by Pease that shells were much more abundant on the leeward than on the windward islands.

Order *PROSOBRANCHIATA*.

Family **Nassidae**.

This family is represented by five species of the genus *Nassa*, all of which are small, none exceeding 16 mm. in length. Only two of the species, *N. orissaënsis* and *N. denegabilis*, are widely distributed in the main area, but *N. labecula* is not uncommon on sandy ground at Nalbano. The other two were taken on a few occasions in the outer channel. The shells were frequently inhabited by the hermit-crabs *Diogenes avarus* and *Coenobita cavipes*.

Nassa sistroidea, G. and H. Nevill, *Journ. Asiat. Soc. Bengal* (2), XLIII, p. 24 pl. i, fig. 6 (1874).

A few living specimens of this species were taken in the outer channel in March and September. *N. sistroidea*, which was described from the Andamans, is probably only an occasional visitor from the sea, though it is apparently able to survive the freshwater season.

Nassa labecula, A. Ads., *Proc. Zool. Soc. London*, 1851, p. 98.

This species is common in the outer channel at all times of the year and was found in abundance with *Potamides fluviatilis* on the shore of Nalbano in March. It is apparently an arenicolous form.

Nassa marrattii, Smith, *Journ. Linn. Soc., Zool.*, XII, p. 543, pl. xxx, fig. 4 (1876).

A single shell was dredged, in a fresh condition, in the outer channel off Satpara Point in September. The species, which has been recorded from the western Pacific,

the Malay Archipelago, the Andamans and the Maldives, is perhaps a casual visitor, but the shell may have been brought from the sea by a hermit-crab.

Nassa denegabilis, Preston, 1914, p. 297, fig. 9; 1915, pp. 290, 480; 1916, p. 28.

This species occurs all over the lake-system on a bottom of mud or muddy sand. The type, which was named, but not described by the late Mr. G. Nevill, is in the British Museum. *N. denegabilis* is found at all times of the year in an active condition. The species is evidently common in estuaries and backwaters on the Indian coasts.

Nassa orissaënsis, Preston, 1914, p. 299, figs. 10, 10*a*; 1915, p. 290.

This is perhaps the commonest and most widely distributed Gastropod in the main area and in the inner part of the outer channel, occurring on a muddy bottom usually among weeds. When placed in a dish of water, specimens often float shell downwards adhering to the surface film by means of the expanded foot. The foot does not conform to the description of the genus given by Fischer[1], for the two posterior lobes, instead of being produced and pointed, are very short, broadly rounded and separated merely by a shallow notch (see fig. 1). This peculiarity may be correlated with the softness of the mud on which the animal frequently crawls. We are under the impression that the foot of *N. denegabilis* is similar, but have no definite note on the subject.

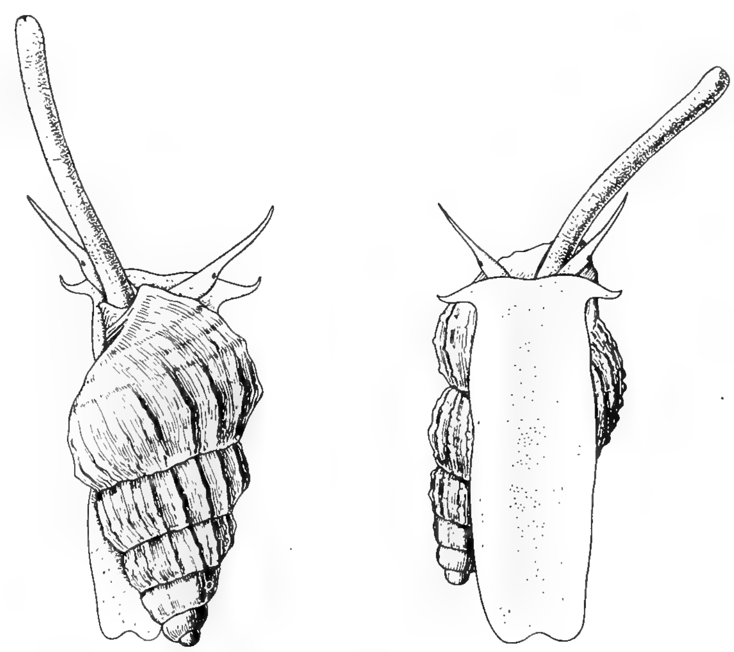

FIG. 1.—*Nassa orissaënsis*, Preston.
Living specimens: *a*, from above: *b*, from below.
(*From sketches made by Mr. G. M. Henry.*)

N. orissaënsis is represented in the Madras backwaters and in canals of brackish water at Calcutta by a large and well-developed variety (var. *ennurensis*, Preston, *Rec. Ind. Mus.*, 1915, p. 479; 1916, p. 28, fig. 2).

Family **Muricidae.**

Thais carinifera (Lam.), Reeve, *Conch. Icon.*, III, *Purpura*, pl. vi, fig. 26 (1845).

In the main area of the lake this species is confined to the rocks at the southern end and to the islands south of Kalidai. It was also found in the outer channel in the salt-water season, but was apparently unable to live in pure fresh water and is not found on the rocks near Patsahanipur. On the oyster-beds at Manikpatna it is fairly abundant in March, but in other places is usually found crawling on rocks. A few

[1] *Manual de Conchyliologie*, p. 633, fig. 389, Paris, 1887.

living individuals were dredged in the middle of the southern part of the lake, perhaps making their way from one set of rocks to another.

T. carinifera is the only Gastropod obtained in the main area whose shell is of any considerable size; the range of the hermit-crabs of the genus *Clibanarius* is therefore co-terminous so far as the main area is concerned with that of *Thais*. The boring sponge *Cliona vastifica* sometimes attacks living shells and the Polyzoa *Alcyonidium mytili* and *Membranipora hippopus* are sometimes found on its surface.

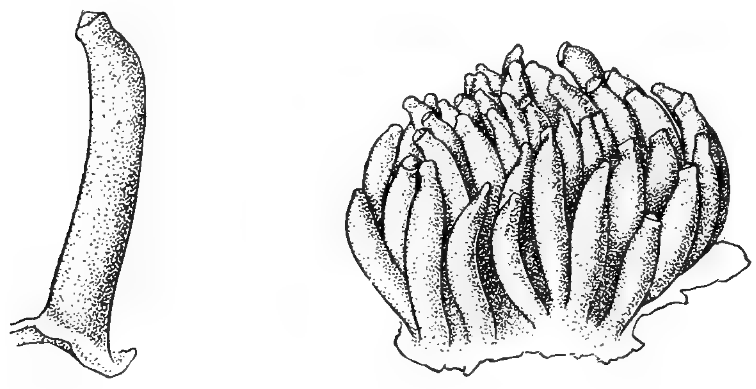

FIG. 2.—*Thais carinifera* (Lam.).

A cluster of egg-capsules (× $2\frac{3}{4}$), with a single capsule more highly magnified.

Eggs, of which we figure a cluster, were observed on the rocks at Ganta Sila in February and on oyster-shells at Manikpatna in March. They were of a dirty yellowish colour when living, but their contents became deep purple when they were placed in alcohol.

Family **Cerithiidae.**

Potamides (*Tympanotonos*) *fluviatilis*, Pot. and Mich., *Gal. de Moll.*, p. 363, pl. xxxi, figs. 19, 20; 1838 (as *Cerithium*).

P. fluviatilis occurs in great abundance along the outer shore of the main area, at Nalbano and in the outer channel. A few specimens were also seen in a small ditch opening into Rambha Bay; but the species is very scarce along the inner shore of the main area. It seems to prefer a bottom of sand or sandy mud and to be able to endure temperatures that are fatal to most other species; it occurred in enormous numbers near the mouth of the outer channel in the freshwater season. Its shell is very commonly occupied by the hermit-crab *Diogenes avarus* and living individuals were occasionally found to which young oysters (*Ostrea* sp.) or small examples of a barnacle (*Balanus amphitrite*) were attached. The hydroid *Clavactinia gallensis* was found on several shells occupied by hermit-crabs, while others, still occupied by their proper owners, were covered by the Polyzoon *Alcyonidium mytili*.

The species is widely distributed in the Indian Ocean and the western parts of the Pacific, occurring usually in brackish water; but according to Mr. Townsend is a distinctly marine form in the Persian Gulf.[1] It was described from the Malabar Coast.

Potamides (*Telescopium*) *fuscum*, Schum., Reeve, *Conch. Icon.*, XV, fig. 1 (1866).

Living specimens were common on some of the islands in the outer channel in March. They appeared to be comatose and many of them were half buried in

[1] See Melvill and Standen, *Proc. Zool. Soc. London*, 1901, p. 375.

caking mud. No specimens were seen in the freshwater season. Mr. Townsend draws attention to the tenacity of life exhibited by this mollusc.[1]

The species is abundant in mangrove swamps on the coasts of India and the Malay Archipelago: in the Gangetic delta the shell is one of those most commonly used for making lime. Dead shells in the outer channel of the Chilka Lake were sometimes occupied by the hermit-crab *Clibanarius padavensis*.

The distribution is similar to that of the former species.

Family **Turritellidae**.

Vanesia rambhaënsis, Preston, 1914, p. 297, figs. 5, 5*a* (as *Terebra*); 1915, p. 289; 1916, p. 32.

V. rambhaënsis is widely distributed on the bed of the main area of the lake and was also taken at the inner end of the outer channel. Although it was originally described from a single specimen the species appears to be gregarious. It was found in large numbers among dead vegetation in Madarchua Bay at the south end of the lake in July. We obtained no specimens in the outer channel in the salt-water season. The species is also known from the Cochin backwaters.

Family **Fossaridae**.

Chilkaïa imitatrïx,* Preston, 1915, p. 291, figs. 1, 1*a*.

Four specimens, including the type of the genus and species, were taken in the inner part of the outer channel in September. Preston remarks on the superficial resemblance of the shell to that of certain forms of *Paramelania* characteristic of the fauna of Lake Tanganyika; but there can of course be no real affinity. The species is evidently very scarce.

Family **Litiopidae**.

Litiopa (*Alaba*) *kempi*,* Preston, 1914, p. 300, figs. 3, 3*a*; 1915, p. 292.

This species occurs sparingly all over the main area of the lake and was found in the outer channel in the freshwater season. It lives among weeds on either a sandy or a muddy bottom.

Litiopa (*Alaba*) *copiosa*,* Preston, 1915, p. 292, figs. 2, 2*a*.

L. copiosa was found in enormous numbers at both seasons of the year in the channels between Barnikuda and Satpara, between the latter place and Mahosa and in Seruanaddi. It also occurred more sparingly in the neighbourhood of Nalbano.

Family **Hydrobiidae**.

This family is represented by one species of *Hydrobia* and six forms of *Stenothyra*, all of which Mr. Preston regards as distinct species. Eleven Indian species of *Stenothyra* are now recognized by him[2], most of which were described from brackish water. It seems not improbable to us that, when large series from different localities

[1] See Melvill and Standen, *Proc. Zool. Soc. London*, 1901, p. 375.

[2] *Faun. Brit. Ind., Freshwater Mollusca*, p. 79 (1915) and *Rec. Ind. Mus.*, XII, p. 31 (1916).

are compared, the number will suffer reduction. It is noteworthy that we found no specimens of *Hydrobia myliacea* or *Stenothyra blanfordiana*, both of which were recorded many years ago from the Chilka Lake and are abundant in other localities. Unfortunately we have no information as to the part of the lake in which they were found.

Hydrobia and *Stenothyra* are the only genera of Molluscs represented in the fauna of the lake that can be said to have limnic affinities.

Hydrobia (Belgrandia) myliacea, Nevill, *Journ. As. Soc. Bengal* (2), XLIX, p. 161 and L, p. 158, pl. vii, fig. 7 (1880-1881).

Nevill records from the Chilka Lake specimens of a form of this species to which he gave, without description, the name "subvar. *subangulata*." Both this form and the typical one were found at Port Canning in the Gangetic delta.

Stenothyra blanfordiana, Nevill, *Journ. As. Soc. Bengal* (2), XLIX, p. 160 (1880) and L, p. 156, pl. vii, fig. 10 (1881).

This species, which was not recognized by Mr. Preston among the specimens we sent him from the Chilka Lake, was described from it by Nevill in 1880. The same author also recorded the species from Port Canning in the Gangetic delta and from Madras. He noted that specimens from the former locality agreed more closely with individuals from the lake than did those from Madras. In parts of the Gangetic delta it is very abundant among weeds.

Stenothyra minima (Sowerby), Preston, *Faun. Brit. Ind., Freshw. Moll.*, p. 81 (1915).

We found this species common among weeds in both parts of the lake-system on both a muddy and a sandy bottom and at all times of the year. It was originally described from western India.

Stenothyra chilkaënsis,* Preston, 1914, p. 300, fig. 1; 1915, p. 293.

S. chilkaënsis is even more common in the lake than the preceding species, together with which it occurs.

Stenothyra orissaënsis,* Preston, 1914, p. 300, fig. 2; 1915, p. 293.

This form occurs with the two preceding; it is perhaps no more than a variety of *S. chilkaënsis*.

Stenothyra trigona,* Preston, 1915, p. 293, fig. 3.

Occurred with the preceding species, but was not found in the outer channel in the salt-water season.

Stenothyra obesula,* Preston, 1915, p. 293, fig. 4.

S. obesula is represented in our collection by a single specimen only; it was obtained in the outer channel in the freshwater season on a bottom of muddy sand.

Family **Scalariidae.**

Epitonium hamatulae,* Preston, 1915, p. 294, fig. 5.

A single dead shell of this species (the type) was found in the outer channel off Barhampur I. in the freshwater season. Its small size renders its introduction by a

hermit-crab improbable and we may suppose that the species is a marine one that occasionally enters the channel in the salt-water season.

Family **Pyramidellidae.**

Pyrgulina humilis (Preston), *Journ. Malacol.*, XII, p. 6, pl. ii, fig. 27; 1905 [as *Pyramidella* (*Mormula*)]; 1915, p. 294 [as *Chrysallida* (*Mormula*)]; 1916, p. 32.

P. humilis, with its variety *chilkaënsis*, Preston (*loc. cit.* 1915) was found in large numbers in the outer channel at all times of the year. A few specimens were also taken S. of Kalidai and off Nalbano. The variety appears to be more common, at any rate in July, than the typical form.

Chrysallida (*Mormula*) *ecclesia*,* Preston, 1915, p 295, figs. 7, 7*a*.

A single living specimen was taken in Madarchua Bay at the south end of the lake in July.

Chrysallida (*Mormula*) *nadiensis*,* Preston, 1915, p. 296, figs. 8, 8*a*.

This species was only found in the outer channel in the freshwater season; it is, however, very scarce and probably occurs at all times of the year in this part of the lake.

Odostomia chilkaënsis,* Preston, 1914, p. 301, fig. 4; 1915, p. 296.

Only two specimens were obtained, both in the outer channel, one at Manikpatna in March and one near Mahosa in September; the latter, however, was a dead shell.

Family **Neritidae.**

Neritina (*Theodoxus*) *souverbiana*, Montrouzier, Montr. and Souverb., *Journ. Conch.* (Paris), XI, pp. 75, 175, pl. v, fig. 5 (1863).

Specimens were found in the outer channel both in March and in September; they were common near Mahosa in the freshwater season, living among weeds. The species, which was described from the China Sea and New Caledonia, is apparently a marine one that in the sea lives among algae.

Family **Cyclostrematidae.**

Cyclostrema (*Tubiola*) *innocens*,* Preston, 1915, p. 296, figs. 9, 9*a*, 9*b*.

A single dead shell (the type of the species) was obtained in Seruanaddi in the freshwater season.

[The shell described by G. Nevill[1] as *Valvata? microscopica*, of which we have examined a long series of co-types, clearly belongs to the same genus as *C. innocens*. It appears to differ from that species only in its smaller size, reddish colour and in the sculpture on its surface; but the type of Preston's species is bleached and perhaps somewhat eroded. We figure (fig. 3) one of the co-types of Nevill's species.]

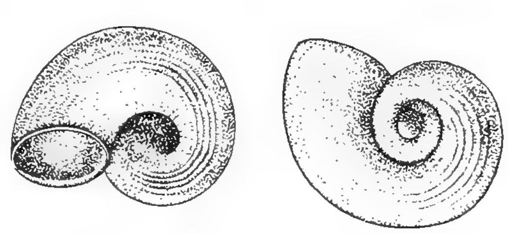

FIG. 3.—*Cyclostrema microscopica* (Nevill).

[1] *Cat. Moll. Ind. Mus.*, fasc. e, p. 21 (1877).

Tinostoma variegatum,* Preston, 1914, p. 302, figs. 6, 6*a*, 6*b*.

A few specimens (including the type) were obtained at Manikpatna in the outer channel in March.

Family **Trochidae.**

Umbonium vestiarum (Linn.), Preston, 1915, p. 297.

Several specimens were found in the outer channel in the salt-water season on sandy ground near the mouth of the lake.

Solariella satparaënsis,* Preston, 1914, p. 302, figs. 11, 11*a*, 11*b*; 1915, p. 297.

This species occurs in the outer channel in the vicinity of Satpara and Barhampur I. at all times of the year, but is rather scarce.

Class **LAMELLIBRANCHIATA.**

Order *TETRABRANCHIATA.*

Family **Ostreidae.**

Ostrea virginiana, Gmelin, Reeve, *Conch. Icon.*, XVIII, *Ostrea*, pl. vi, fig. 9; 1873 (as *O. rostrata*). Plate xiv, fig. 2.

We have already discussed the beds formed by this oyster in the outer channel of the lake (p. 336). It is an extraordinarily hardy species and can endure desiccation, even when exposed to a tropical sun, for considerable periods as well as immersion in fresh water. We have also observed it living in similar conditions in backwaters near Madras, at the head of Port Blair harbour in the Andamans and in a lagoon on the Gulf of Siam.

We have to thank Mr. E. Vredenburg of the Geological Survey of India, who is engaged in a study of the oysters of this group, for the information embodied in the following note.

The specimens from the four localities referred to above seem to belong to a smaller race of a very large oyster (probably the largest living species) which is known to occur abundantly at many points along the south coasts of Asia, from the Mekran to the Malay Peninsula. Mr. Vredenburg is of opinion that, taking into account the variability in the shape of oysters generally, it is not possible to discover in the shape, the build, the ornamentation, the proportions or the dimensions of these shells, any differences sufficiently precise to afford an excuse for separating the form specifically from *Ostrea virginiana*, Gmelin, a very common shell along the Atlantic coast of North America. The species seems to be practically cosmopolitan throughout the warmer seas.

Certain forms occurring in the Bay of Bengal, including that named *O. gryphoides* var. *cuttackensis* and found on the Orissa coast, were separated from *Ostrea virginiana* by Messrs. Newton and Smith (*Rec. Geol. Surv. Ind.*, XLII, pp. 1-15; 1912) (*a*) on account of differences in shape or build which Mr. Vredenburg considers inadequate for specific distinction in such variable organisms, and (*b*) on account of the absence of the deep purple-black or purple-brown colour which, in North

American shells, suffuses parts of the valves, especially the muscular scar. This pigment is certainly absent in the large variety from Cuttack, but it is developed[1] to a most pronounced degree in the specimens which we have lately obtained from the Chilka Lake, the Andamans, Madras and Siam. The absence or presence of the colour is probably due to circumstances of environment. Amongst many species of *Ostrea* the colour is very variable.

The Cuttack shell is regarded by Newton and Smith as specifically identical with a fossil form from the miocene of Europe, *Ostrea gryphoides*, Schlotheim (better known as *Ostrea crassissima*, Lamarck) the close affinity of which to the species living along the coast of North America has been commented upon by every palaeontologist who has had occasion to deal with the form. In most instances specific identity between the fossil form and the living *Ostrea virginiana* has not been admitted. The identity would, nevertheless, have to be conceded, if, on the one hand, we accept Mr. Vredenburg's identification of the living Indian shell with the North American *Ostrea virginiana*, and, on the other hand, Messrs. Newton and Smith's reference of the living form to a miocene species. Mr. Vredenburg, while admitting that there exists the closest relationship between the living and tertiary forms, is not prepared to admit actual specific identity without further research. In any case, as regards nomenclature, if the identity of the Indian and American species is accepted, the specific name *virginiana* is older than any of the others bestowed upon its fossil relatives.

Mr. Preston regards the small Indian form with deep pigmentation of the inner surface as specifically distinct and has described it under the name *O. madrasensis*.[2]

Ostrea lentiginosa, Sowerby, Preston, 1910, p. 36.

A few shells of this species from Manikpatna have been identified by Mr. Preston.

Ostrea cucullata, Born, *Test. Mus. Caesarei Vindobon.*, p. 114, pl. vi, figs. 11, 12 (1780).

Individuals of this common oyster are sometimes found attached to clumps of *O. virginiana* on the beds at Manikpatna (see pl. xiv, fig. 2).

Ostrea sp.

Several shells of a flat circular form were found attached to the post in the channel off Satpara to which reference has already been made. Unfortunately they have been mislaid, but there can be no doubt that they represent a species different from any of those recorded above.

Family **Mytilidae**.

Mytilus smaragdinus, Chemnitz, Reeve, *Conch. Icon.*, X, *Mytilus*, pl. vii, fig. 28 (1858).

A single small shell, in a fresh condition but empty, was found on the oyster-beds at Manikpatna in fresh water. The animal had evidently entered the lake in a larval condition, but had been unable to survive the floods. The species is very com-

[1] The corresponding soft parts of the animal are similarly pigmented.

[2] *Rec. Ind. Mus.*, XII, p. 33, figs. 11, 11*a* (1916).

mon on the east coast of India and grows in great luxuriance on the stone-work of Madras Harbour. The distribution extends from Hong Kong to the Arabian Sea.

Modiola undulata (Dunker). *See* p. 358.

Modiola striatula, Hanley. *See* p. 360.

Family **Arcidae.**

Arca (*Anadara*) *granosa*, Linn., Lamy, *Journ Conch.*, LV, p. 210 (1907). Plate xvi, figs. 3-6.

Shells are abundant in a subfossil condition at the head of Rambha Bay, on Barkuda I. and at many other places in both parts of the lake; but the animal is extremely scarce in a living condition. Living and fresh specimens with the epidermis still complete were taken on only three occasions,—off Samal I., off Kalidai and near Barkul, in March and September. The largest of these is only 26 mm. in breadth, whereas a large shell from the Nicobars exceeds 75 mm. The subfossil specimens are intermediate in size, not exceeding 50 mm., while shells of about this size were seen with the epidermis still present in the outer channel in March.

We have referred above (p. 339) to von Neumayer's observations on a dwarfed form of this species that occurs in a subfossil condition in the Yang-tse-Kiang delta. *A. granosa* is frequently found living in brackish water on the coasts of India and Malaysia, but the larger specimens in the Indian Museum all seem to come from marine localities. It may therefore be assumed that dwarfing is correlated in this species with decrease in the salinity of the water; in the Chilka Lake the process seems to have been progressive and to have commenced while the south end of the lake was still in communication with the sea. The case is one of the best illustrations with which we have met, of the gradual change that has taken place in the fauna of the lake in the course of its comparatively short geological history.

The species has a distribution extending from the Arabian Sea to Japan and Australia.

Arca (*Fossularca*) *lactea*, Linn., Lamy, *Journ. Conch.*, LV, p. 97 (1907).

A few living specimens were dredged in the channel between Satpara and Barhampur I. in March and a dead shell was taken at the same locality in September. They occurred on a bottom of muddy sand. It seems probable that the species is killed off annually towards the close of the monsoon by the irruption of fresh water. *A. lactea* is a common European and E. Atlantic mollusc and has been recorded from Ascension I., S. Africa, the Red Sea and various Indian localities; also somewhat doubtfully from the Philippines.

Family **Erycinidae.**

Kellya chilkaënsis,* Preston, 1915, p. 298, figs. 10, 10*a*.

This species is apparently scarce, but living specimens were found in both parts of the lake,—near Kalidai and Patsahanipur in March and in the inner part of the outer channel, both in this month and in September.

Kellya mahosaënsis,* Preston, 1915, p. 298, fig. 11.

K. mahosaënsis is represented in our collection by the type specimen only, a minute shell found with typical *K. chilkaënsis* in the outer channel.

Family **Galeommidae.**

Scintilla chilkaënsis,* Preston, 1915, p. 299, figs. 12, 12*a*.

S. chilkaënsis was not uncommon near Satpara and Barhampur I. in the freshwater season on a bottom of mixed sand and mud, but was not found in salt water.

The mantle closely resembles that of *S. hydatina*, Deshayes, as figured by Lynge [1]; the papillae on its margin being long and finger-shaped. The mantle was yellow and the tentaculiform marginal papillae were pale with deep orange tips, those of *S. hydatina* being described as deep red.

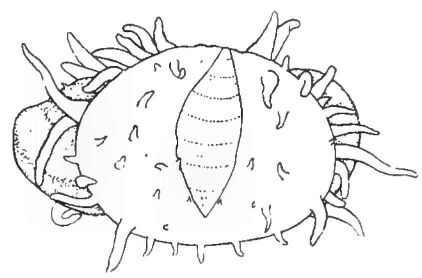

FIG. 4.—*Scintilla chilkaënsis*, Preston.

Specimen with mantle expanded, covering the greater part of the shell (from an example preserved in spirit).

Family **Cardiidae.**

Cardium (*Fulvia*) *rugatum*, Gron., Reeve, *Conch. Icon.*, II, *Cardium*, pl. xii, fig. 63 (1843).

A few young molluscs of this species were taken just inside the mouth of the lake in salt water. *C. rugatum*, like *Mytilus smaragdinus*, is doubtless an occasional visitor to the outer part of the lake-system in the salt-water season.

Family **Veneridae.**

This family is represented by no less than seven species (four genera), but only one form, *Clementia annandalei*, now occurs living in the main area of the lake. At least one other, *Meretrix casta* [2], is abundant in a subfossil condition at the head of Rambha Bay and on Barkuda I.

Meretrix meretrix (Lam.), Reeve, *Conch. Icon.*, XIV, *Cytherea*, pl. iii, fig. 10; 1864 (as *C. impudica*).

Common in the outer channel.

Meretrix casta, Chemn., Reeve, *Conch. Icon.*, XIV, *Cytherea*, pl. vii, fig. 25 (1864); syn. *Corbicula* (*Velorita*) *satparaënsis*, Preston, 1914, p. 306, fig. 22.

Blanford [3] states that this species is characteristic of estuarine waters on the Indian coasts. It is still fairly common in the outer channel of the Chilka Lake, where it buries itself in a bottom of mixed sand and mud, and probably occurs

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[1] *Danske Vid. Selsk. Skr.* (7), *nat. og math.*, V, iii, p. 186 (1909).

[2] There seems to be great confusion as to the Indian species of this genus and it is possible that a further systematic study will considerably alter the synonymy at present accepted.

[3] *Rec. Geol. Surv. Ind.*, V, p. 61 (1872).

throughout the year. Its habits render it difficult to obtain except when the water is low. Both young and old individuals were found.

Meretrix ovum, Hanley, Reeve, *Conch. Icon.*, XIV, *Cytherea*, pl. vi, fig. 19 (1864).

This species is more common than the preceding in the outer channel, both young and old individuals occurring in great abundance on the same ground and also on clear sand nearer the mouth of the lake. *M. ovum* was described from Malabar.

Tivela dillwyni (Deshayes), Reeve, *Conch. Icon.*, XIV, *Cytherea*, pl. vii, fig. 24 (1864).

A single small living specimen was obtained in Seruanaddi in the freshwater season.

Tapes pinguis, Chemn., Mart. and Chemn., *Conch. Cab.*, *Veneracea*, p. 126, pl. v, figs. 3-5, 8-10; 1869 (as *Vernes*).

The species is fairly common in the outer channel with *M. casta* and *M. ovum* in March and probably at other times of the year.

Tapes ceylonensis, Sowerby, Mart. and Chemn., *Conch. Cab.*, *Veneracea*, p. 236, pl. xl, figs. 10, 11 (1869).

The same remarks apply to this species as to the last.

Clementia annandalei, Preston, 1914, p. 306, figs. 14, 14*a*, 14*b*; 1915, p. 301.

All over the main area of the lake this is one of the commonest molluscs, occurring in mud with *Theora opalina*. In the inner part of the outer channel it is less abundant, its place being taken to some extent by species of *Diplodonta*. Living individuals were dredged at all times of the year, but it was noticed that dead shells were relatively very abundant at the end of the freshwater season. The shell is so brittle that it is difficult to obtain perfect specimens, but is much less transparent than that of the *Theora*.

The species also occurs at Port Canning in the Gangetic delta and has long been represented in the collection of the Indian Museum by large numbers of specimens from this locality labelled with the *nomen nudum* "*Clementia blanfordii*, Benson." The genus is characteristic of estuarine waters in the tropics of Africa and Asia.

Family **Petricolidae.**

Petricola esculpturata,* Preston, 1915, p. 301, figs. 13, 13*a*.

This mollusc was found only in crevices between oyster-shells on the beds at Manikpatna in the outer channel. It was obtained both in fresh and in salt water.

Family **Ungulinidae**

Only two of the five species of *Diplodonta* by which this family is represented were found in the main area of the lake. Considering the fact that several species are known from the Gulf of Siam, all of which have a wide Oriental distribution, it is remarkable that all the Chilka forms should prove to have been undescribed. The first three species in the following list seem to prefer a bottom of sandy mud, but *D. ovalis* and *D. chilkaënsis* live chiefly on clean sand.

Diplodonta satparaënsis,* Preston, 1915, p. 302, figs. 14, 14*a*, 14*b*.

Dead shells of relatively large size were abundant in the inner part of the outer channel at all times of the year. A few living specimens of smaller size were taken in this channel in the salt-water season, and at the same season a few small living individuals were found near Kalidai I.

Diplodonta barhampurensis,* Preston, 1915, p. 302, figs. 15, 15*a*.

Represented only by a pair of empty valves (the type) taken in the inner part of the outer channel in the freshwater season.

Diplodonta (*Felania*) *annandalei*,* Preston, 1914, p. 307, figs 20, 20*a*, 20*b*; 1915, p. 303.

An abundant species at the inner end of the outer channel and also found in the main area in the neighbourhood of Nalbano, off Patsahanipur, near Kalidai and at Maludaikuda. As is the case with *D. satparaënsis*, living specimens were found only in the salt-water season, while fresh but empty shells were obtained in fresh water in September.

Diplodonta (*Felania*) *ovalis*,* Preston, 1914, p. 308, figs. 19, 19*a*, 19*b*; 1915, p. 303.

A few individuals were found at Manikpatna and near the mouth of the lake, while one was taken in the inner part of the channel near Barhampur I. No specimens were obtained in the freshwater season.

Diplodonta (*Felania*) *chilkaënsis*,* Preston, 1914, p. 308, figs. 21, 21*a*, 21*b*; 1915, p. 303.

Except for one living specimen taken on the southern side of the Satpara peninsula, all our examples of this species, which are not numerous, were obtained towards the seaward end of the outer channel on clean sandy ground. A single living individual was found with a number of dead shells in September, 1913. Most of the shells dredged in the freshwater season were dead.

Family **Psammobiidae.**

Psammobia mahosaënsis,* Preston, 1915, p. 303, figs. 16, 16*a*, 16*b*.

This species is not uncommon in the inner part of the outer channel. Living individuals were found in both the salt and the freshwater season.

Family **Solenidae.**

In the Chilka Lake we found three forms of *Solen* that must be provisionally regarded as distinct species, but we believe that until the anatomy of the Oriental forms of the genus has been investigated, it will remain impossible to assign specific limits with any degree of certainty. Our reason for making this statement is the fact that in the collection of the Indian Museum, only a small proportion of which is named so far as this genus is concerned, we find many forms that seem to grade one into the other. Moreover at several localities on the Indian coasts pairs of forms occur, resembling one another closely except in the proportions of their shell, the relative dimensions being less different at some places than at others. Two forms of this

kind, which Mr. Preston has called *S. annandalei* and *S. kempi* occur in the outer channel of the lake and at Nalbano, while a third (*S.* ? *jonesi*) which is relatively shorter than either, is one of the most abundant species of Lamellibranchs in the main area. Shells of the two former are found together and both would seem to burrow only in sandy ground, whereas the third is essentially an inhabitant of soft mud. *S. annandalei* and *S. kempi* are comparatively scarce and, with the exception of a single small specimen of the latter, are represented in our collection by dead shells only. Dr. Ekendranath Ghosh describes the general structure of *S.* ? *jonesi* in considerable detail in the appendix on pp. 367-374.

? *Solen jonesi*, Dunker, Preston, 1916, p. 37; syn. *S. truncatus*, Preston, 1914, p. 309. Plate xvi, fig. 7.

In his paper of 1914 Mr. Preston regarded this shell as a young form of *S. truncatus*, Wood, which it resembles in outline. Many sexually mature individuals were, however, found that were no larger than those examined by him.

We obtained in the Chilka Lake no shell more than 28·5 mm. long and, in a series of specimens that we have measured, we find that the length varies from $3\frac{1}{3}$ to a little more than $3\frac{1}{2}$ times the breadth.

Von Martens[1], who regards *S. jonesi* as synonymous with *S. woodwardi*, Dunker, notes that Dunker's specimens were from 51 to 53 mm. long and 11 to 12 mm. broad; Reeve's figure is 59 mm. long and 12 mm. broad. Von Martens concludes that small specimens are about $4\frac{1}{2}$ times as long as broad, and larger ones as much as 5 times. If Mr. Preston's identification is correct, the Chilka race is evidently a dwarfed one.

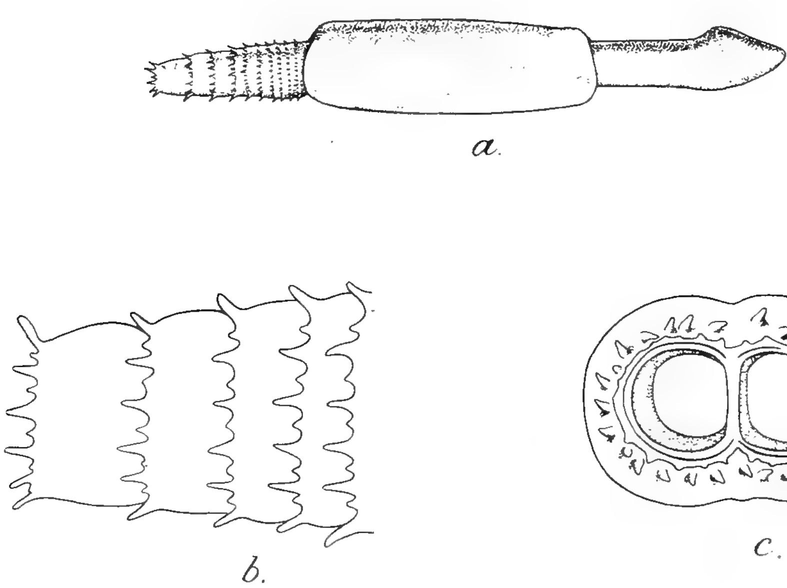

FIG. 5.—Chilka race of *Solen* ? *jonesi*, Dunker.

a. A living specimen, slightly enlarged, with extruded foot and siphon.
b. A portion of the siphon, more highly magnified, lateral view.
c. A cast-off section of the siphon, end view.

The question of proportions in this and closely allied species is, however, one of great difficulty. Three valves found on a sandy beach at the mouth of the Ennur backwater near Madras and identified by Mr. Preston as *S. jonesi*, are respectively about 86, 72 and 71 mm. long. The first of these is $5\frac{3}{4}$ times as long as broad and the other two about $4\frac{1}{2}$ times—measurements and proportions that do not by any means tally with those given by von Martens.

[1] Weber's *Zool. Ergebn. Nied. Ost.-Ind.*, IV, p. 279 (1897).

For the greater part of the year the little *Solen* is extremely abundant in the lake and numbers were brought up in most hauls of our nets. Even when the shells were absent, the peculiar siphons to which we refer below were often found. At the end of the wet season, however, it was difficult to obtain living specimens, and only a few were seen at this time of the year.

The animal excavates, in the ordinary manner, a vertical burrow that is not very much deeper than its own length, inserting its foot into the mud in a contracted condition and then expanding it so as to force an entrance. If laid on its side it can right itself instantaneously by turning its foot round at an angle and thus getting a purchase on the bottom. It can dart rapidly for some inches backwards by squirting water from its siphon and can also swim forwards with moderate ease, compressing its foot laterally and using it as a paddle.

The most remarkable feature in the structure of the species lies in the great development of the siphons, in their very distinct segmentation, in the arrangement by which the segments are thrown off either singly on in groups by a process of autotomy, and in the existence of a ring of minute tentacles round the distal end of each segment. Apart from the actual shortening effected by the autotomy of one or more segments, it produces no apparent structural or functional disablement of the siphons, and if, as seems not improbable, the tentacles have a sensory function, the new tip is as well equipped as the old.

The small form of *Solen ? fonesi* occurs in the backwaters of Cochin as well as in the Chilka Lake. The species is recorded from the Philippines and Cebu, but without particulars.

Solen annandalei,* Preston, 1915, p. 304, figs. 17, 17*a*. Plate xvi, fig. 8.

The shell of this form is easily distinguished from Chilka specimens of *S. ? fonesi* by its larger size and relatively greater length; in the only two specimens we have seen the length is respectively 4·7 and practically 5 times the breadth. The shells were found on sandy beaches at Nalbano and Satpara, in both cases with examples of *S. kempi*.

Solen kempi,* Preston, 1915, p. 305, figs. 18, 18*a*. Plate xvi, fig. 9.

The shell is still narrower than in *S. annandalei*, the length being from 6·4 to about 7 times the breadth. Several fresh shells were found at Satpara and Nalbano and a single living example was dug from pure sea-sand near the mouth of the lake. The siphons resembled those of *S. fonesi*, but the animal, instead of being practically colourless, had a distinct greenish tinge.

Family **Mactridae**.

Standella annandalei,* Preston, 1915, p. 305, figs. 19, 19*a*, 19*b*.

This species is common on sandy ground at Nalbano, burrowing to a depth of several inches. It also occurs in the outer channel, in which, however, we took only dead shells. The only living specimens we obtained were taken in March, but the habits of the species render it difficult of capture except when the level of the lake

is very low. A polychaete worm of the genus *Diopatra* frequently fixes a single valve of the shell to the upper extremity of its tube, which projects in the form of a vertical funnel above the surface of the sand.

Family **Myidae**.

Corbula chilkaënsis,* Preston, 1911, p. 39, fig. 2.

This species is represented in our collection by a single specimen, the type, taken living under a stone at the edge of the lake near Rambha in March, 1910. It bears a remarkably close resemblance to some species of *Cuspidaria*. The interior of the shell has not been examined and we are by no means certain of the true systematic position of the species.

Family **Pholadidae**.

Martesia striata (Linn.), Reeve, *Conch. Icon.*, XVIII, *Pholas*, pl. viii, figs. 32, *a, b, c.* (1873).

In the old collection of the Indian Museum there are several small and distorted valves of this species, labelled "Chilka Lake." It is a cosmopolitan form common in drift-wood in the Bay of Bengal and the specimens probably came from a log that had drifted into the mouth of the lake.

Family **Teredinidae**.

Xylotrya stutchburyi, Sowerby, Reeve, *Conch. Icon.*, XX, pl. ii, figs. 5, 5*a*, *b*, *c* (1878).

A post standing in the lake near Satpara was bored through and through by this ship-worm. Many of the tubes were empty and one of them was occupied by a small blenny of the genus *Petroscirtes*; some were lined by the Polyzoon *Membranipora hippopus*.

Order *DIBRANCHIA*.

Family **Tellinidae**.

We obtained no living representatives of this family; but the shells of the following two species were apparently quite fresh at the time they were collected.

Tellina chilkaënsis,* Preston, 1915, p. 306, figs. 20, 20*a*, 20*b*.

A single pair of fresh valves was obtained in the inner part of the outer channel in the freshwater season.

Tellina confusa,* Preston, 1914, p. 309, figs. 18, 18*a*.

We obtained no specimens of this species, which has long been represented in the Indian Museum by examples from the late Dr. Blanford's collection, labelled *T. aequistriata*, Sowerby. They are probably from the outer channel of the lake.

Family **Scrobiculariidae**.

Theora opalina (Hinds), *Proc. Zool. Soc. London*, 1843, p. 78.

This is quite the most abundant bivalve mollusc in the main area of the lake. It occurs more sparingly in the inner part of the outer channel. The shell lies buried

in mud, or muddy sand, and the siphons are capable of elongation to at least three times its length; but so far as we could discover the burrow is always quite superficial. The animal is capable of giving sudden leaps by ejecting water. The shell when not eroded is of a glassy transparency (see fig. 6) but becomes somewhat clouded after death.

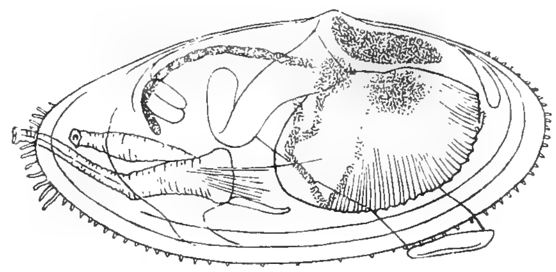

FIG. 6.—*Theora opalina* (Hinds). Living animal, with siphons contracted and foot partially extruded. From a sketch by Mr. G. M. Henry.

Theora opalina was originally described from a muddy bottom in shallow water in the Philippines. It probably occurs in all estuaries and backwaters on the Indian coasts, at any rate it is fairly common in those of Bengal, Madras and Cochin.

Cumingia hinduorum,* Preston, 1915, p. 308, figs. 22, 22*a*.

This species was found living at the inner end of the outer channel at all times of the year. Living specimens were also obtained off Parikudh in the main area in November in water of very low salinity (sp. gr. 1·00225), the bottom at this point being somewhat sandy.

Family **Cuspidariidae.**

Cuspidaria annandalei, Preston, 1915, p. 308, figs. 23, 23*a*, p. 482; 1916, p. 39.

This species is common all over the lake-system except at the seaward end of the outer channel. It sometimes occurs on bare mud, but is particularly abundant in thickets of *Potamogeton*, to which young shells are frequently found attached. It seems to flourish equally well in fresh, salt and brackish water. Many shells have a number of small greyish spots on the swollen part; these are more conspicuous in fresh examples. The species has also been found in backwaters at Madras and Cochin and in the Gangetic delta.

Family **Lyonsiidae.**

Lyonsia samalinsulae,* Preston, 1914, p. 310, figs. 16, 16*a*; 1915, p. 309.

There are not many specimens of this species in our collection; but they were found living at widely separated places in the outer channel and the main area both in the salt and fresh-water seasons. Their scarcity is probably due to the fact that they burrow in sandy mud near the shore and were therefore rarely taken in our nets.

Family **Anatinidae.**

Broken shells belonging to the genus *Anatina* were observed in considerable numbers on the shore, when the level of the lake was low, wherever a certain amount of sand was mixed with the mud of the bottom. Good specimens were difficult to obtain on account of the fragility of the shells and of the fact that the animals burrow to a depth of at least two feet.

Lynge draws attention to the variability of *A. anatina* (Linn.) and expresses the opinion that many species of the genus will ultimately have to be withdrawn. We

have found it very difficult, with all the types before us, to distribute fresh specimens among Preston's three species.

Anatina granulosa,* Preston, 1914, p. 310, figs. 17, 17*a*.

The species was described from a specimen long in the Indian Museum and labelled merely "Chilka Lake." We attribute to it with some doubt a much larger shell found dead on the shore at Ganta Sila in March.

Anatina barkudaënsis,* Preston, 1915, p. 309, figs. 25, 25*a*.

Under this name Preston includes the majority of our specimens; they were found in all parts of the lake except the sandy area of the outer channel. All our living examples were taken in the salt-water season, but the only manner in which we were able to obtain them was by digging on the shore when the water level was low.

Anatina barkulensis,* Preston, 1915, p. 309, figs. 24, 24*a*.

A living specimen was dug up at Ganta Sila in February, and another was dredged near Mahosa in the outer channel in September. The type, obtained at Barkul Point in March, was dead but in a fresh condition.

NOTE ON VARIATION IN *MODIOLA*.

The great abundance of *Modiola* in the Chilka Lake and the conspicuous nature of the variability exhibited by its species has enabled us to prepare notes on this genus of a more elaborate kind than those we have given on other Mollusca.

Modiola is a genus of cosmopolitan distribution and wide bathymetric range. *M. watsoni* is common in the Bay of Bengal at a depth of over 100 fathoms and several forms have been found in inland lakes in eastern Asia. In the estuaries of Indian rivers at least one species is abundant, *viz.* that referred to below as *M. striatula*, Hanley.

In the large series of specimens we obtained in the Chilka Lake it is possible to select individual shells corresponding with those referred by Mr. Preston to nine species and one variety; but, for the reasons stated below, we are convinced that at most only two variable species of different habits are represented. We should mention that only a comparatively small proportion of the shells were available at the time that the collection was examined by Mr. Preston.

Modiola undulata (Dunker).

(Plate XV, figs. 1—6: plate XVI, fig. 1.)

1856. *Volsella undulata*, Dunker, *Proc. Zool. Soc. London*, XXIV, p. 363.
1858. *Modiola undulata*, Reeve, *Conch. Icon.*, X, *Modiola*, pl. v, fig. 18.
1911. *Modiola chilkaënsis*, Preston, *Rec. Ind. Mus.*, VI, p. 41, fig. 6.
1914. *Modiola undulata* and var. *crassicostata*, Preston, *ibid.*, X, p. 304, fig. 15.
1915. *Modiola undulata* and var. *crassicostata*, Preston, *ibid.*, XI, p. 298.

This species is abundant in the Chilka Lake, occurring at all seasons and in all parts of the lake-system. It is almost invariably attached either to *Potamogeton*, to filamentous or delicately branching algae or to the ropes of fishing traps; in other

words to objects that sway freely in the water. The algae may be growing on stones and of no great length and a few living shells were found apparently lying free on a muddy bottom, but they may have been shaken from weeds by the net. Large numbers of dead shells were noted in December on the shore at Rambha after a strong breeze.

The shell in specimens of *M. undulata* from the Chilka Lake is thin, as a rule semi-transparent and lightly tinged with yellowish-green; markings when present, as they usually are, are of a bright reddish-purple. There is considerable variation in outline; but the upper margin is always strongly elevated at or near the middle and is sometimes subangulate: the exact position of this point is not always the same. On account of the elevation the proportional depth of the shell is always considerable, but in this character also there is much variation. The lower margin of the shell is often quite straight, but perhaps more frequently very slightly concave: it is never emarginate. In some specimens one valve is a little more inflated than the other, but this peculiarity is sometimes so slight as to be almost imperceptible and may exist in either valve. The type of Mr. Preston's *M. chilkaënsis* (pl. xv, fig. 5) is an individual in which it is particularly well marked, but his figure exaggerates the asymmetry.

The surface of the shell is usually devoid of radiating ridges, except immediately in front of and below the umbo, where there are distinct transversely-striated costae. Faint traces of similar costae are, however, often to be observed on the posterior edge of the shell and occasionally extend along its whole length in a well-developed condition. It is to this form that Mr. Preston has given the name var. *crassicostata* (pl. xv, fig. 6).

In the commonest type of colouration the shell is marked with zig-zag purple lines, which run transversely and are frequently interrupted, and also with finer straight radiating lines of the same colour. Lines of both kinds frequently disappear almost completely on the lower half of the shell and the longitudinal ones are almost always most strongly developed on the posterior half. Both kinds of lines may be obsolete or even entirely absent and the whole surface of a uniform pale yellowish-green; shells of this type are not uncommon. On the other hand the purple lines often develop into irregular blotches, and occasionally the whole surface, except the extreme margin, becomes deeply suffused with purple pigment, definite markings being indistinguishable. This type of colouration is, however, very rare. Photographs illustrating variation in colour-pattern are reproduced on Plate xv, figs. 1-4.

The shells described by Dunker evidently belong, so far as colouration is concerned, to the form commonest in the Chilka Lake, but Reeve has figured and described a unicolourous specimen which appears to have been browner than any in our collection. Our descriptions of colour have, however, been drawn up from specimens preserved in spirit, in which the differences are much better seen than in dried shells.

Neither in colouration, shape, degree of asymmetry or presence or absence of ribs on the surface are we able to find correlation of any kind, and specimens from

the same handful of weed may possess any combination of the peculiarities mentioned. It is very probable that the inequality of the valves characteristic of Mr. Preston's *M. chilkaënsis* is due to unequal pressure at an early stage of growth, the crowded condition of the shells (pl. xvi, fig. 1) easily explaining how this may have occurred.

There seems to be very little difference between our specimens of *M. undulata* and those described by Dunker and Reeve. The former author gives the length of the shell as 11 lines (about 23 mm.) and our largest specimens are of exactly the same size. Only a few individuals, however, attain these dimensions, the circumstances in which they live making it impossible for the majority of them to exist for a prolonged period. A large number of those individuals that are attached to the stems of *Potamogeton* must perish with that plant, which dies down in June or July, though it is possible that some are able to transfer themselves to the roots, which of course persist. In this position there is great danger of their being overwhelmed by mud. Those individuals, on the other hand, that are attached to filamentous algae growing on stones are mostly killed by desiccation in spring or early summer.

We have no evidence, therefore, in the case of this species that its abnormal environment in the Chilka Lake has produced anything of the nature of a racial dwarfing or distortion. It is naturally a variable species, as is proved by the apparent discrepancies in Dunker's and Reeve's descriptions, both authors having had before them specimens from the same locality (the Moluccas) and collection. We are not aware that the species has been recorded from any other Indian locality but the Chilka Lake; but we have specimens from Port Canning in the Gangetic delta.

Modiola striatula, Hanley.

(Plate XV, figs. 7-18; plate XVI, fig. 2.)

1842-56. *Modiola striatula*, Hanley, *Cat. Recent Bivalve Shells*, p. 241, pl. xxiv, fig. 29.
1858. *Modiola striatula* and *emarginata* (Benson MS.), Reeve, *Conch. Icon.*, X, *Modiola*, pl. x, figs. 72, 73.
1909. *Brachyodontes emarginatus*, Lynge, *Danske Vid. Selsk. Skr.* (7) *nat. og. math.*, V, p. 135.
1909. *Modiola cochinensis*, Preston, *Rec. Ind. Mus.*, III, p. 278, fig. 2.
1910. *Modiola jenkinsi*, Preston, *ibid.*, V, p. 36, fig. 5.
1911. *Modiola annandalei* and *celator*, Preston, *ibid.*, VI, pp. 40, 41, figs. 4, 5.
1914. *Modiola emarginata*, Preston, *ibid.*, X, p. 304.
1915. *Modiola taprobanensis*, Preston, *Ann. Mag. Nat. Hist.* (8), XVI, p. 84, fig.
1916. *Modiola taprobanensis*, Preston, *Rec. Ind. Mus.*, XII, p. 35.

The synonymy of this species presents great difficulties, owing, we are convinced, to the extreme variability of the shell. Among the specimens from the Chilka Lake Mr. Preston has recognized no less than four species, while in our more recent collections we find selected shells that agree precisely with his types of two others. We are by no means certain that the synonymy we give is exhaustive, for it seems not at all improbable that, when large series from estuarine tracts and lagoons in the Oriental region are compared, it will be found that other forms at present regarded as distinct fall well within the limits of variation of *M. striatula*. It is noteworthy, moreover,

that in a small series of *M. lacustris*, von Martens, from the Tung-ting Lake in China, we find variations in the shape of the shell comparable to those that occur in the species from the Chilka Lake.

M. striatula differs from *M. undulata* so far as habits are concerned in that it is usually found attached to rocks, stones, wooden posts or other solid objects. This is the case in the Gangetic delta as well as in the Chilka Lake. Shells are occasionally found in both places fastened to algae growing on stone, but seem to be unable to attain their full development in this position. In the Gangetic delta a favourite situation is on posts partly destroyed by *Xylotrya*; but the mussel is also found on brick-work in the Calcutta docks, where it is stated to do considerable damage by settling in cracks in the bricks and splitting them by its growth. In the Chilka Lake it prefers to settle in crevices in rocks or among oyster-shells. We have noticed on many occasions that the young molluscs show a marked tendency to congregate round the adults (pl. xvi, fig. 2).

In the lake it is extremely abundant in both the outer channel and the main area and occurs at all times of the year, being very common in all suitable places whenever the rocks and oyster-beds are covered with water.

Near Calcutta, where it is very abundant, it is frequently overwhelmed by the sponge, *Spongilla alba*, in which we occasionally found shells in the Chilka Lake. On the bottom of our steam-launch large numbers were also discovered in the sponge *Suberites sericeus*.

The shells that we have included under the name *M. striatula* vary very greatly in shape, sculpturing, size and colouration, but we find from the old collection of the Indian Museum that all, or practically all, were included by G. Nevill under the name *M. emarginata*, Benson. This name seems to have existed in manuscript some time before it was published by Reeve, and it was the one by which the common mussel of the estuaries of the Bay of Bengal was known to Blanford[1] and his contemporaries. Nevill gives *striatula* as a synonym on his labels.

From *M. undulata* the species appears to be distinguished by the following characters, though in certain cases we have found it very difficult to separate individual shells of small size. The shell is always more opaque and as a rule much more densely pigmented, the pigment being of a duller shade. The upper margin is as a rule less strongly elevated and more evenly arched, the proportional depth of the shell being therefore less. The postero-dorsal margin is as a rule more declivous and the posterior extremity more narrowed and less strictly horizontal. In a large number of shells the ventral margin is boldly excavated or emarginate. Radial ridges, which are exceptional in *M. undulata*, are usually present; but the anterior margin is sometimes quite smooth.

The nominal species that we include under *M. striatula* may be divided into two groups, (i) those in which the lower margin of the shell is practically straight and (ii) those in which it is distinctly excavated. The former consists of *M. cochinensis* and

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[1] Blanford, however, distinguished some specimens as *M. striatula*.

M. jenkinsi, Preston, the latter of *M. striatula*, Hanley; *M. taprobanensis*, Preston; *M. emarginata*, Reeve; *M. annandalei* and *M. celator*, Preston. In practically every series of specimens we have examined, either from the Gangetic delta or from the Chilka Lake, there is a complete transition between these two groups, and many of the specimens identified by Blanford and by Mr. Preston as *M. striatula* have the lower margin straight, while in Reeve's figure it is much more nearly so than in Hanley's. In fact, so far as it is possible to say without seeing those of *M. striatula* and *M. emarginata*, we believe that the types could be arranged in the following order so as to form an almost complete series in this respect:—

1. *M. jenkinsi.*
2. *M. cochinensis.*
3. *M. striatula.*
4. *M. taprobanensis.*
5. *M. emarginata.*
6. *M. celator.*
7. *M. annandalei.*

With the concavity of the lower margin in these forms a relative narrowing and elongation of the whole shell is often correlated and in those types in which this margin is straightest, the relative depth of the shell is greatest. *M. taprobanensis*, however, is a rather broad form.

The type of *M. celator* is remarkable for its abnormal outline as seen in dorsal view and for the thickened and eroded condition of the antero-superior region of the shell. We find precisely similar shells in a number of our series and also others in which abnormalities of a similar nature occur in other parts. Photographs of abnormal shells and of the types of four species described by Mr. Preston are included in the series figured on pl. xv, figs. 7-18.

The development of radial costae is an extremely variable character, but the surface is less frequently quite smooth than in *M. undulata.* In many specimens the costae are quite as fully developed as in the var. *crassicostata* of that species, but they are never branched as in *M. subramosa*, Hanley. Another variable character is the development of concentric growth-lines; abnormal specimens occur, especially in forms resembling *M. celator*, in which they are greatly accentuated. Sculpturing of the shell is not, however, correlated in any way with its shape. It seems to us impossible to recognize *Branchyodontes*, Swainson, even as a subgenus.

The colouration is also very variable, but the variation is not quite of the same nature as in *M. undulata*, the different colours being as a rule more diffused as well as duller. In some specimens, however, zigzag transverse purple lines and longitudinal striae can be detected, but the purple is usually less red and the ground-colour of a bluer green. Young specimens are as a rule brighter than adults and fully developed shells are sometimes of an almost uniform dull brown.

Perhaps the best illustration we possess of correlation between different forms of shell and their environment is a worm-eaten log covered with mussels of this species. It has long been in the Indian Museum and almost certainly came from the Gangetic delta. Among the shells from this log are some that are relatively short and broad and have the lower margins perfectly straight, while others exhibit every degree of

length of shell and concavity of margin. The former are those which repose in comparatively short cavities with a smooth lining and straight or nearly so, while the latter are esconced in deeper holes of irregular shape and are pressed either against one another or against the walls. In each case the shell takes the shape of the space it occupies; in some instances it forms practically a cast of that space and the degree of concavity of the lower margin is most strictly correlated with the degree of curvature of the surface against which it is pressed.

In the Chilka Lake we noticed exactly the same phenomenon. Shells with a straight margin, like the types of *M. jenkinsi* and *M. cochinensis*, were those which were attached to flat objects such as the inner surfaces of oyster-shells, while extreme forms such as *M. annandalei* were living in crevices in rocks or on uneven stones. The byssus is always very short and the shell is pressed closely against the object of attachment. In the case of forms resembling Mr. Preston's *M. celator*, we believe that we are dealing merely with abnormalities produced by growth in unusally confined spaces. The shell is always greatly thickened and eroded on the surface, either all over or in parts.

Colouration is to some extent correlated with environment, shells from rocks or logs overgrown with algae being paler and greener than those on bare stone of a dark shade, while those on the inside of oyster-shells are often quite pale; the correlation, however, is not of a precise nature. Specimens from some localities, *e.g.* the Cochin and Madras backwaters, are browner than those from the Chilka Lake. They have been named by Mr. Preston, *M. cochinensis* and *M. taprobanensis* respectively.

The shell seems to be thicker in specimens from marine localities than in those from estuaries and backwaters.

All our specimens from the Chilka Lake are small, exceptionally large shells not exceeding 20 mm. in length, while in many series none reach 15 mm. The largest specimen from the log of wood to which we have referred above is 31·5 mm. in length, others from the Andamans are scarcely smaller, while Reeve figures an individual 39 mm. long and von Martens[1] notes that the largest he examined was 36 mm.

It is clear, therefore, that all the individuals we found in the Chilka Lake are dwarfed and we are convinced that our investigations were sufficiently exhaustive in this respect to include the whole range of variation. There is, however, a small series of specimens in Blanford's collection, labelled as coming from the Chilka Lake, some of which are more than 35 mm. in length. It is unfortunate that no precise information is available as to their *provenance*, but in general appearance they bear a remarkably close resemblance to those on the log of wood referred to above; we have good reason to suspect that they may have been introduced on driftwood.

Specimens from the backwaters of Cochin and Madras are even smaller than those from the Chilka Lake, rarely, if ever, exceeding 10 mm. in length, but in these places they live in confined spaces between the valves of dead oyster-shells. Those from the Chilka Lake oyster-beds are almost as small. Among those we have our-

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[1] Weber's *Zool. Ergebn. Nied. Ost-Ind.*, IV, p. 227 (1897).

selves found in small pools near Calcutta liable to desiccation, none exceed 23 mm. in length. There are several other series in the collection of the Indian Museum from the Gangetic delta which include shells 31 mm. long, but we are ignorant of the precise circumstances in which they were found.

From all these facts it would seem that the small size of the mussels of this species found in the Chilka Lake is in no sense a racial character, but is due to the direct effect of environment on the individual. We must remember that by far the greatest part of the rock-area available on the shores and islands of the lake is completely dried for several months in the year, at any rate from March until the latter part of June. At the end of the dry season extremely few living individuals are to be found and these are situated in close proximity to the muddy bottom and are therefore liable to be buried. From the situation in which the young mussels establish themselves it necessarily follows that the chief, though not the only, breeding season must occur shortly before the adults are killed by the sinking of the water-level and that the larvae settle down when the lake is full. It is interesting to notice that they do so at a time when the water is quite fresh or but very slightly saline.

The situation most favourable to the growth of *M. striatula* seems to necessitate the following conditions,—(i) a firm support provided with cavities in which the animals may attach themselves; (ii) the absence of any risk of being engulphed in mud or in living sponges and (iii) an uninterrupted supply of water. There is of course the question of food-supply also, but on this we have no information. To judge from the specimens we have examined, ideal conditions are to be found on worm-eaten logs of wood, either fixed beneath the lowest water-level or floating.

It is not improbable that the species is essentially an estuarine one, but in spite of this fact, ideal conditions exist very rarely, if at all, in the Chilka Lake. We are of the opinion that dwarfing in the case of *M. striatula* in the lake is not due to the low salinity of the water and that there is no evidence that the unfavourable conditions noted in the preceding paragraphs have affected the race as distinct from the individual.

M. striatula was originally described from the Philippines and has been recorded from the Gulf of Siam, Singapore, Ceylon, Burma and from both sides of the Indian Peninsula (Calcutta, Madras, Cochin, Bombay).

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APPENDIX.

THE ANATOMY OF THE COMMON *SOLEN* OF THE CHILKA LAKE.—? A DWARFED FORM OF *S. FONESI*, DUNKER.

By Ekendranath Ghosh, *M.Sc., Asst. Professor of Biology, Medical College, Calcutta.*

The anatomy of *Solen fonesi* has been described briefly by Bloomer[1], but he gives few details of the internal structure and does little more than compare the foot, mantle, etc., with those of *S. vagina*. No detailed account of *S. vagina* is available in Calcutta and there are no specimens in spirit in the Indian Museum. It has therefore seemed best merely to describe the different organs of the form from the Chilka Lake and leave it to other malacologists more favourably situated as regards literature and material to decide whether the identification is correct.

In one point this form differs markedly from that described by Bloomer, *viz.*, in the entire absence of pigment on the external surface of the foot and mantle.

SHELL.

Shell thin, translucent, very brittle, with a brownish epidermis, corroded in its upper anterior portion (upper anterior quadrant), length about three and a half times the breadth; anterior margin straight and directed from above a little forwards, with a rounded antero-inferior angle; posterior margin straight and nearly vertical; a single narrow elongated umbonal tooth just behind the antero-superior margin in the right valve.

Anterior adductor impression elongately triangular, with the base oblique and directed in front; anterior retractor impression small, rounded and just below the anterior end of the anterior adductor impression. Posterior adductor impression small, rounded, just a little in front of the postero-superior angle; posterior retractor impression rounded, of the same size as that of the posterior adductor and placed just in front of the latter.

ANATOMY.

In preparing the following description I have had recourse to the following methods:—

(1) Two relatively large specimens have been dissected; the structures have been followed with the naked eye and with the help of the dissecting microscope.

(2) Three medium-sized specimens, taken out of their shells, have been dehydrated in absolute alcohol, and cleared in clove oil. The mantle-lobes, gills, and the

[1] *Journ. Malac. Soc. London,* VII, p. 18 (1906).

labial-palps of one side were then removed and the animal was examined under a low power. The coils of the intestine, the ganglia, some of their commissures, and the general outline of the kidneys were well made out by this method.

(3) Lastly, a complete set of serial sections was cut by the paraffin method from one end of the animal to the other, and stained as usual. The arrangement and the relation of the various structures made out in the serial sections were compared with the results obtained by other methods.

I. MANTLE-LOBES.

The anterior margins are thick and straight and run a little forward from above; they are separate from one another in their full lengths so as to leave an oval gap for the foot. The separation extends beyond the antero-ventral corner for a short distance as a rounded notch. The ventral margins are united and thickened, although less so than the free anterior borders. The posterior margins are thickened and united to form a single siphon containing both the inhalent and exhalent canals.

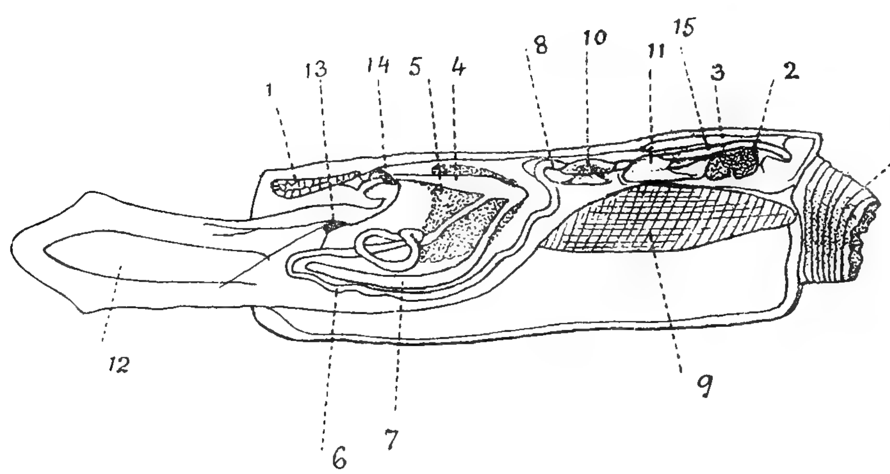


FIG. 1.—*Solen ? jonesi*, Dunker.

1. anterior adductor muscle; 2. posterior adductor muscle; 3. posterior retractor muscle; 4. stomach; 5. liver; 6. intestine; 7. pyloric caecum; 8. rectum; 9. gill (inner); 10. heart; 11. kidney; 12. pedal sinus; 13. pedal ganglion; 14. cerebral ganglion; 15. visceral ganglion; 16. remains of siphons after autotomy.

II. SIPHON.

The siphon consists of the fused inhalent and exhalent canals. When complete it consists of at least ten segments, each of which is wider at the base than at the apex. Each segment is at its distal border fringed with small conical tentacles, about 20 in number and arranged in a single row (see text-fig. 5, p. 354). When complete and fully extended, the siphon reaches a length nearly equal to that of the animal in the shell. When fully retracted and when a part has been thrown off the siphon lies very slightly protruded from the posterior border of the mantle-lobes. In the retracted state, the distal segment is less contracted than the others, forming a tumid rounded border bounding the inhalent and exhalent apertures. The tentacles are retracted and turned inwards towards the apertures.

Minute structure (figs. 2, 3).—In a transverse section, the siphon consists of a thick wall with a transverse band separating the apertures (text-fig. 2).

The wall consists of the following layers :—

(1) An outer layer of columnar cells situated on a distinct basement membrane.

(2) A thick layer of connective tissue with many elastic fibres and connective tissue corpuscles. The fibres are mostly arranged circularly and radially in narrow bundles at regular intervals. They are continued into the next layer.

(3) A thick longitudinal layer of muscles fibres grouped into radial bundles by radial and longitudinal partitions of connective tissue which extend from the second layer to the next. The muscular layer is divided into an outer and an inner portion by a thin circular layer of connective tissue fused with the radial ones at their points of crossing. This thin layer of connective tissue is united on both sides by a thin layer of the same tissue, which forms the middle of the thick transverse partition between the inhalent and exhalent canals. At the junction of the two lie two blood-sinuses, one on either side. On either side of this median layer lies a narrow longitudinal layer of muscular tissue continuous with the inner portion of the longitudinal layer of muscular fibres in the wall of the siphon.

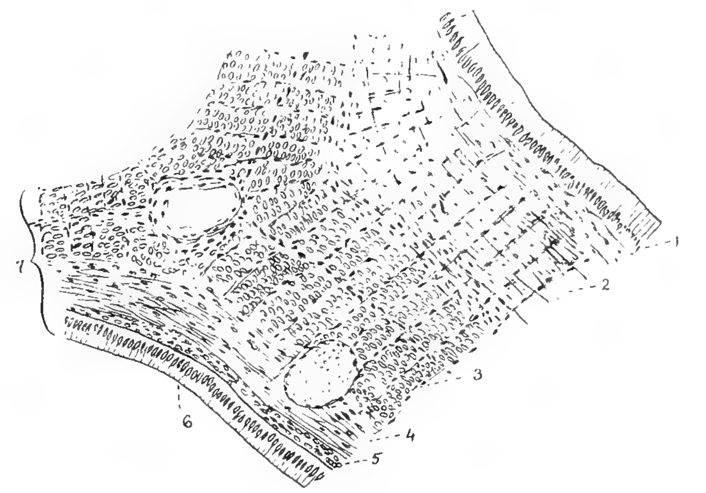


FIG. 2.—*Solen ? jonesi*, Dunker.

Transverse section of the wall of the siphon.

1. outer epithelial lining; 2. outer layer of connective tissue; 3. longitudinal layer of muscles; 4. transverse layer of muscles; 5. longitudinal layer of muscles; 6. epithelial lining of the inhalent tube of the siphon; 7. part of transverse partition.

(4) A thin layer of connective tissue which is interrupted at the junction of the outer wall of the siphon with the transverse partition. In this layer and abutting on the next outer muscular layer are blood-sinuses and nerves disposed in the following manner :—The blood-sinuses are 4 in number—two lateral already referred to, and one in the mid-dorsal and one in the mid-ventral line. The nerves are 12 in number, three on each side of the inhalent and three on each side of the exhalent aperture.

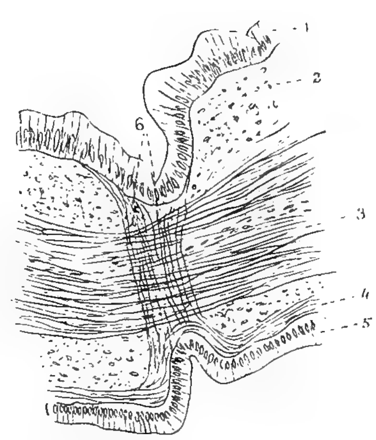


FIG. 3.—*Solen ? jonesi*, Dunker.

Longitudinal section through wall of siphon at junction of two contiguous segments.

1. outer epithelial lining; 2. outer layer of connective tissue; 3. longitudinal layer of muscles; 4. inner longitudinal layer of muscles; 5. inner epithelial lining; 6. radial layer of muscles.

(5) A thin layer of transverse muscle-fibres surrounding the inhalent and exhalent canals. This layer is much thicker in the situation of the transverse partition than in the wall of the siphon.
(6) A thin layer of longitudinal muscle fibres.
(7) A thin layer of transverse muscle fibres.
(8) A layer of columnar epithelial lining of the inhalent and exhalent canals.

The structure of the wall of the siphon at the junction of the contiguous segments (text-fig. 3) differs from that of the wall of the segments themselves in the following particulars:—

(1) The wall is much narrowed down.
(2) The connective tissue layer beneath the outer epithelial lining has disappeared.
(3) The inner thin transverse layer of muscles is absent.
(4) A radial layer of muscle fibres pass from beneath the outer epithelial lining inwards to the epithelium lining the apertures.

The process of autotomy which occurs in the siphonal tube between the contiguous segments thus seems to be due to the voluntary contraction of the radial muscles which cut through all the other layers of the body-wall, thus separating one or more distal segments from the proximal portion of the siphon. Even in the case of spirit specimens the segments can be easily separated from one another.

III. FOOT.

The foot is elongated and cylindrical, and is a little flattened from side to side; it is incapable of retraction within the mantle-lobes. The organ is stouter towards the apex than towards the base, where it forms a distinct rounded annular swelling and still further a conical process at the tip. When fully protruded, the foot has its length a little less than that of the body (mantle-lobe). There is a wide pedal-sinus along the middle of the foot.

IV. LABIAL PALPS.

The labial palps are shaped like an obtuse-angled triangle, the longest side of which is a little curved and forms the lower border of the organ. The shortest side of the triangle is attached to the side of the visceral mass at its junction with the mantle-lobe. The measurements of the palp-margins (in a specimen 2·5 cm. in length) are 0·45, 0·3, and 0·2 cm., respectively.

V. GILLS.

The gills are narrow and elongated; their posterior ends are slightly prolonged into the base of the inhalent canal. The outer gill extends from the postero-inferior angle of the labial palp; the inner gill extends further forwards, and begins from behind the postero-superior angle of the palp. This anterior portion of the inner gill is overlapped by the palps.

The attachments of the gills are best described in a table:

Outer gill.	
Outer lamella ..	Attached to the mantle-lobe, the non-glandular portion of the kidney, and to the glandular portion behind the visceral mass; to the non-glandular portion at the level of the visceral ganglia, and lastly to the mantle-lobe again.
Inner lamella Inner gill. Outer lamella	Attached to the under-surface of the non-glandular portion of the kidney, and to the glandular portion posteriorly.
Inner lamella ..	Free; beyond the visceral ganglion attached to the inner lamella of the opposite inner gill.

VI. Digestive System.

The transverse slit-like *mouth* lies just behind and towards the ventral aspect of the anterior adductor muscle.

The *oesophagus* passes horizontally backwards to end in the stomach. Beneath the ventral aspect of the anterior two-fifths of the oesophagus is a space bounded below by the base of the foot, laterally by the labial palps, and behind by the visceral mass. Just behind the upper and lower lips of the mouth the oesophagus has a cuticular lining continuous with a similar, but less prominent, lining of the stomach.

The *stomach* is elongately pyriform in shape, and is rounded posteriorly. Behind and from its ventral aspect is given off a hollow tubular structure, the *pyloric coecum*, which descends into the visceral mass. The pyloric coecum passes to the right side lying on the inner side of the right wall of the visceral mass. It then curves forwards and passes to the front, lying still on the right side and parallel to the coil of the intestine. It then crosses the middle line and passes to the left side where it ends blindly at a point about midway between the junction of the two anterior loops of the intestine and the junction of the foot with the visceral mass. The position of the pyloric coecum varies slightly with the condition of the foot as regards its contractility. When the foot is fully extended, the coecum lies at the same level with the lowest loop of the intestine, but when it is more or less retracted, it lies above the loop.

The *intestine* begins from the ventral aspect of the stomach just in front of the origin of the pyloric coecum. It passes forwards and a little downwards along the right side of the middle line and curves downwards and then backwards in front of the base of the foot. It then runs backwards along the left side of the middle line and then bends upwards lying on the inner side of the first loop. It then takes another curve and passes a little forwards and then suddenly turns backwards and again downwards and forwards, and passes on straightly forwards crossing the middle line to the right side into the foot to the junction of its anterior two-thirds and posterior one third, where it bends downwards and backwards beneath the pyloric coecum. Lastly the intestine curves round the posterior end of the stomach to reach the posterior portion of the dorsal aspect of the latter and then curves out of the visceral mass to enter the pericardial chamber and form the rectum.

The *rectum* as usual passes through the ventricle in the pericardial chamber over the posterior adductor muscle to end in the anus.

The *liver* surrounds the stomach. Ventrally it extends beyond the first loop of the intestine to the dorsal aspect of the pyloric coecum. Anteriorly it extends to the close coils of the intestine.

VII. Nervous System.

The *cerebral ganglia* are fusiform in shape, and are placed obliquely on the side of the gullet, the posterior lower end lying just behind the groove at the base of the foot. Each ganglion lies just above the junction of the inner and outer lamellae of the outer and inner labial palps.

The cerebral ganglia are joined to one another by an *intercerebral connective* lying transversely over the oesophagus as usual.

The *cerebro-pedal commissure* passes downwards just behind the junction of the foot with the visceral mass and joins the pedal ganglion of the same side. The direction of the cord varies according to the condition of the foot; when the foot is fully extended, the cord is directed downwards and forwards from the cerebral ganglion, but it is directed downwards and backwards when the foot is retracted.

The *cerebro-visceral commissure* passes backwards lying just above the attachment of the inner and outer lamellae of the outer and inner labial palps. As it passes backwards it penetrates the wall of the visceral mass obliquely and comes to lie on the inner side of the wall at the anterior end of the gills. It runs backwards, lying along the attachment of the gills, and is gradually displaced upwards till it comes to lie on the inner side of the kidney between it and the wall of the visceral mass beyond the posterior loop of the intestine. It then comes to lie beneath the kidney towards its outer side. In its further course it is gradually displaced towards the inner side and lies between the kidney and the posterior retractor muscle of the foot. Lastly the two cords lie side by side till they end in the visceral ganglia.

The *pedal ganglia* are closely applied to one another, lying in the middle line towards the dorsal aspect of the foot at its base a little in front of the mouth. When the foot is retracted, the ganglia recede backwards and come to lie considerably behind the cerebral ganglia. Three nerves can be followed from each pedal ganglion:

(1) Passes horizontally forwards and divides into two branches which can be traced beyond the middle of the foot.

(2) Passes obliquely forwards and downwards to the middle of the foot.

(3) Passes downwards and a little forwards towards the ventral aspect of the foot.

The *visceral ganglia* are closely applied to one another and are placed between the two posterior retractors of the foot and beneath the rectum. The ganglia are displaced forwards from the posterior adductor muscles. The two posterior pallial nerves can be traced to the undersurface of these muscles.

VIII. Vascular System.

The *pericardial chamber* is elongated, and is much narrowed down and compressed posteriorly over the rectum.

The *heart* occupies the anterior half of the pericardial chamber, the *ventricle* corresponding to the posterior end of the last intestinal loop in the visceral mass. The *ventricle* is fusiform in shape. The two *auricles* are trapezoid in shape; of the two parallel sides, the shorter one is attached to the ventricle and the longer one to the base of the gill.

IX. Excretory System.

Each *kidney* is U-shaped with the loop placed posteriorly. The *glandular portion*, lying beneath the pericardium, begins at a point behind the middle of the ventricle. In the first part of its course the kidney is tubular and narrow and is placed on the dorso-lateral aspects of the non-glandular portion and the visceral mass just above the attachment of the gills. It then suddenly widens out into a bulbous portion, pushing the gills downwards and outwards and lying on the outer side of the non-glandular sac and on the dorso-lateral aspect of the hindermost portion of the visceral mass and the ventro-lateral aspect of the rectum, both the two latter structures being applied to the glandular sac. Anteriorly the bulbous portion is crescentic in transverse section, the concave side being placed on the dorso-lateral aspect of the hindermost part of the visceral mass and the cerebro-visceral nerve cord. Just before the formation of the posterior retractor muscle of the foot, the bulbous portion widens out more on the inner aspect and communicates with the opposite one through the inter-renal aperture. At this point the bulbous portion surrounds the rectum on its ventral and lateral aspects. Gradually the inter-renal aperture widens out, while the glandular sac surrounds the rectum more closely and completely. The pericardial chamber is much narrowed down and flattened out, occupying the dorsal aspect of the rectum. The glandular sac now recedes from the rectum and is displaced ventral-wise by the interpolation of the two posterior retractor muscles which lie by the side of the middle line, being separated by a median vertical partition extending from below, where two glandular portions meet at their inner borders to the side of the rectum above, to end in the mantle-lobe. Lastly the glandular portion becomes narrowed down again and ends in the non-glandular portion by a small narrow slit.

From the dorsal aspect of each of the two glandular sacs where they communicate with one another at their ventral aspects, a diverticulum is given off, which passes backwards for a short distance surrounding the ventral and lateral aspects of the rectum, the dorsal aspect being occupied by the pericardial chamber.

The non-glandular portion is very wide at its origin at the level of the visceral ganglia, occupying the whole width between the attachments of the gills on either side. It extends a little backwards beyond the posterior end of the glandular sac. As it runs forwards, it occupies the outer side of the glandular sac and is gradually displaced, at first to the ventral and lastly to the inner side of the glandular sac, separated from each other at this place by a wide interval. The non-glandular sac extends a little beyond the glandular sac at its anterior end.

X. Reproductive System.

The gonads form irregular branching masses beneath the dorsal wall of the foot in its anterior two-thirds and both along the lateral and the dorsal aspects in its posterior one-third; the lateral group passes upwards to the ventral aspect of the gullet and extends backwards to the anterior end of the liver. The mass extends backwards on the inner side of the lateral walls of the visceral mass in the middle third of its lower half on the outer side of the coils of the intestine. Posteriorly behind the liver and the coils of the intestine, the gonads are more numerous and nearly fill the cavity of the visceral mass.

EXPLANATION OF PLATE XIV.

Oysters from Indian backwaters.

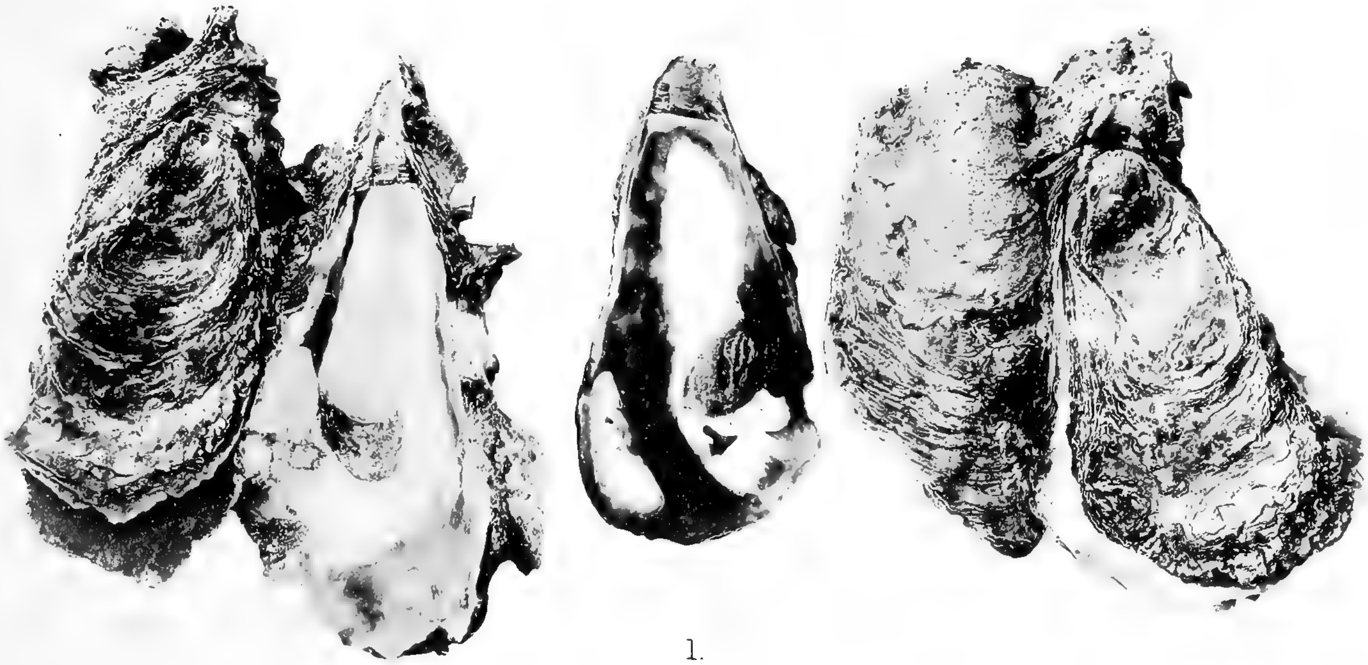
FIG. 1.—Shells of *Ostrea virginiana,* Gmelin, from Ennur backwater near Madras: slightly reduced.

,, 2.—A clump of *Ostrea virginiana,* Gmelin, along with a specimen of *O. cucullata,* Born., from the Chilka Lake: slightly reduced.

The inner surfaces of the valves of *O. virginiana* show the deep purple pigmentation characteristic of most living individuals of the species.

Remains of the corals from the Chilka Lake.

FIG. 3.—Portion of a stone from the south-eastern side of Rambha Bay bearing skeletal remains of Turbinolid corals, a group of animals not now found in a living condition anywhere in the lake: natural size.



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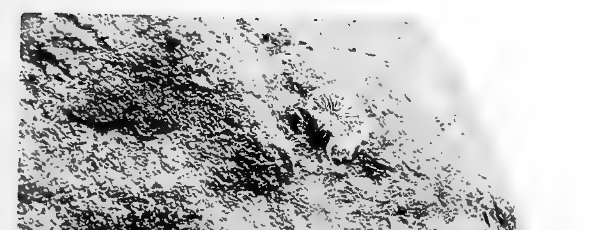

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Photo by S. C. Mondul.

Bemrose, Collo, Derby

OYSTERS AND REMAINS OF CORALS.

EXPLANATION OF PLATE XV.

Photographs of shells of *Modiola* from brackish water on the coast of India.

Modiola undulata (Dunker).

FIGS. 1-4.—Variously coloured specimens from a single handful of weed from the outer channel of the Chilka Lake (September, 1914).

FIG. 5.—Type of *M. chilkaënsis*, Preston, from algae growing on stones at Breakfast I., Chilka Lake.

,, 6.—Type of *M. undulata* var. *crassicostata*, Preston, from weeds growing on bottom off Samal I., Chilka Lake.

Modiola striatula, Hanley.

FIG. 7.—Type of *M. jenkinsi*, Preston, from oyster-shell from Manikpatna, Chilka Lake.

,, 8.—Specimen from the Chilka Lake identified by Blanford as *M. striatula* var. (identification confirmed by Preston).

,, 9.—Type of *M. cöchinensis*, Preston, from oyster-shell from Cochin backwaters, near Ernakulam.

,, 10.—Specimen from the Chilka Lake identified by Blanford as *M. emarginata*, Benson.

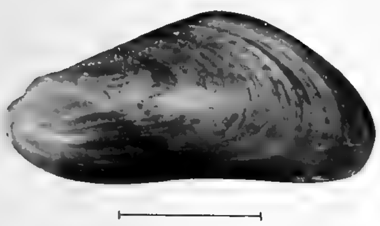
,, 11.—Type of *M. annandalei*, Preston, from stone from Chilka Lake near Rambha.

,, 12.—Type of *M. celator*, Preston, from worm-eaten driftwood from the beach at Puri, Coast of Orissa.

FIGS. 13-15.—Three specimens from a worm-eaten log, probably from the Gangetic delta.

,, 16-18.—Abnormal specimens from Port Canning, Gangetic delta, identified by Nevill as "*M. striatula*, Hanley (= *M. emarginata*, Benson)."

Specimens 1—4 were photographed in spirit; the other figures are from dried shells. The line below each figure shows the actual length of the shell.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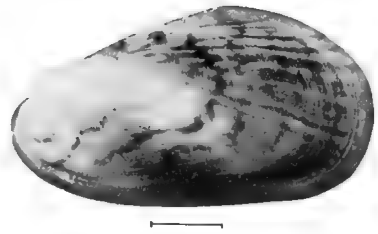
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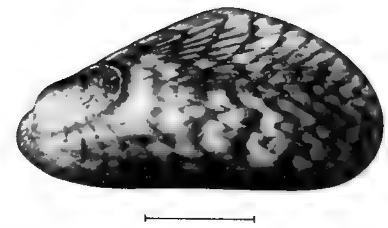
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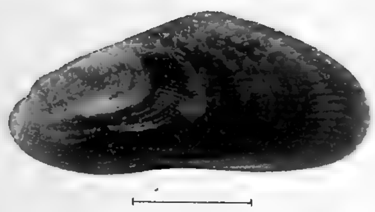
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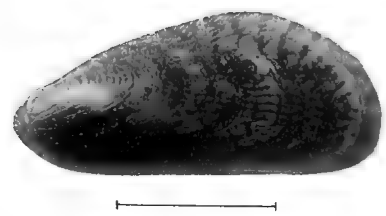
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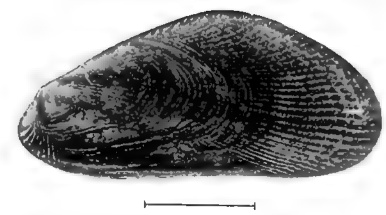
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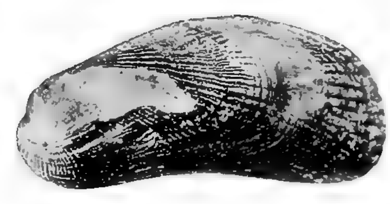
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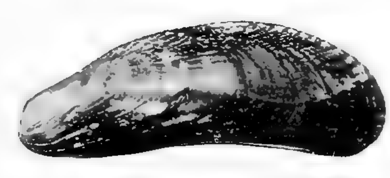
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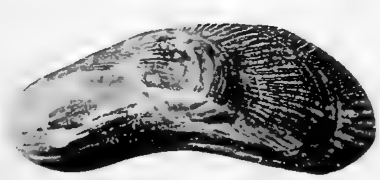
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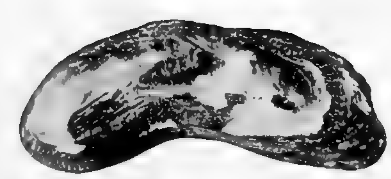
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Photo. by S. C. Mondul.

VARIATION IN MODIOLA.

Bemrose, Collo, Derby

EXPLANATION OF PLATE XVI.

Modiola undulata (Dunker).

FIG. 1.—Cluster of young shells on weed from off Barnikuda I., obtained in September, 1914.

Modiola striatula, Hanley.

FIG. 2.—Dead oyster-shell from Manikpatna, taken in December 1914, showing young mussels settling round adults.

Arca granosa, Linn.

FIG. 3.—Subfossil valve from Barkuda I., Chilka Lake.
,, 4.— ,, ,, ,, head of Rambha Bay, Chilka Lake.
,, 5.— ,, ,, ,, Manikpatna, Chilka Lake.
,, 6.—Fresh valve from off Samal I., Chilka Lake.

Solen ? Jonesi, Dunker.

FIG. 7.—A specimen from the southern end of the Chilka Lake.

Solen annandalei, Preston.

FIG. 8.—Type specimen.

Solen kempi, Preston.

FIG. 9.—Type specimen.

All the figures are natural size.

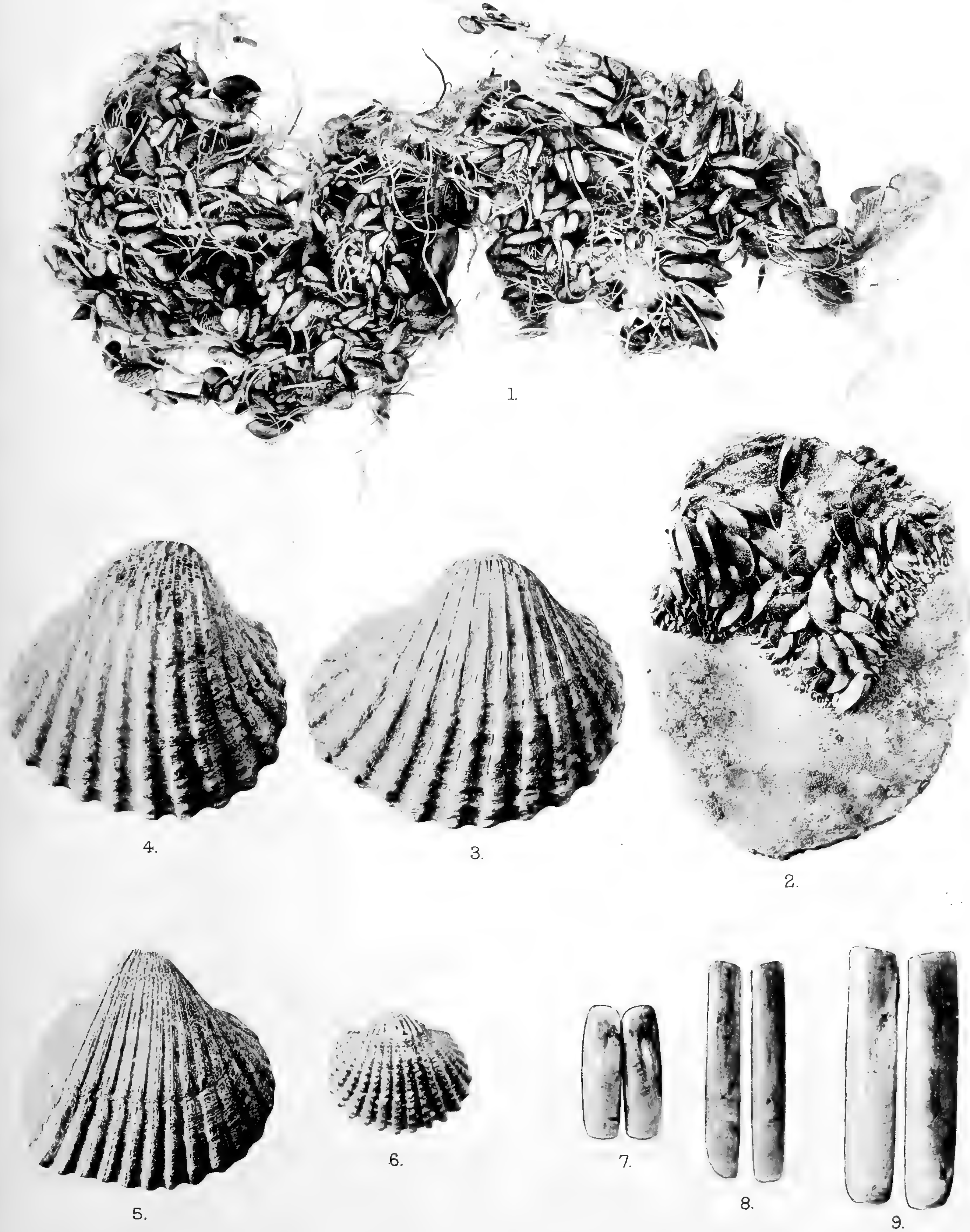

Photo. by S. C. Mondul.

Bemrose, Collo, Derby

MOLLUSCA OF THE CHILKA LAKE.

FAUNA OF THE CHILKA LAKE

MOLLUSCA NUDIBRANCHIATA.

By Sir Charles Eliot, *M.A., D.C.L. LL.D., K.C.M.G., C.B., Principal of the University of Hong Kong.*

(With 1 text-figure.)

CONTENTS.

MOLLUSCA NUDIBRANCHIATA.

By SIR CHARLES ELIOT.

The Nudibranchs collected by Dr. Annandale and Mr. Kemp in the Chilka Lake consist of three specimens, namely two small Aeolids and an *Elysia*. Both species must be treated as new. They may possibly be identical with animals known to us only by the figures and slight descriptions of older naturalists, but they do not correspond exactly with any such figures and descriptions.

Cuthona annandalei, a member of the same genus of Aeolids, has been found in brackish water in the mouths of the Ganges and *Alderia modesta*, a form allied to *Elysia* though not very nearly, is known to inhabit brackish marshes in the British Isles.

Cuthona henrici, sp. nov.

The notes on the living animal are as follows :—

"Two specimens (with drawing from life of one[1]) from off Ganta Sila in the main area of the Chilka Lake, 28-xii-1913.

Colour yellowish-white; cerata dark olive-green with variable black markings at their base.

The specimens were dredged in about five feet of water from among weeds on a muddy bottom just off the rocks of Ganta Sila. When placed in a dish they floated in the surface-film back downwards and moved along rapidly in this position.

They probably feed on the Hydroid *Bimeria fluminalis*, Annandale.

Specific gravity of water (corrected) about 1·006."

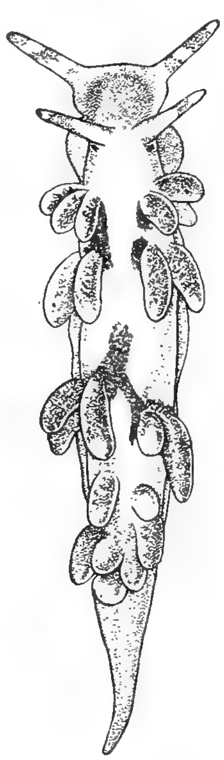

FIG. 1.—*Cuthona henrici*, sp. n. × 15.
Drawn from life by Mr. G. H. Henry.

The preserved specimens correspond to the above description, but the bodies appear to have shrunk more than the cerata, making the latter seem relatively larger. The colour has become a dull yellowish-brown. The large specimen is bent, but would be about 10 mm. long if straightened.

The oral tentacles are large and distinct. The rhinophores are of about the same size, cylindrical and smooth,

[1] The drawing was made by Mr. Henry of the Colombo Museum who is alluded to in the specific name.

without a trace of perfoliations. The cerata are rather thick and some are almost ovate. They are set in four groups. The first, second and third groups are divided into two halves, containing two or three cerata on the right and left respectively. The fourth is a clump of seven cerata disposed irregularly across the back. The vent is on the right side about half way down. The shape of the body is elongate and the tail is moderately long. The foot is expanded into a distinct margin all round the body. In front it is rounded and ample, but not produced into horns or other appendages.

The cutting edge of the jaws bears a single row of denticles, blunt and shaped rather irregularly. The radula consists of a single row containing 27 yellowish teeth, of which two are still in process of formation. The teeth are of the horse-shoe shape with a moderately strong central cusp. On either side of it there are usually seven denticles. Of these five are long, pointed and conspicuous. The outermost and that nearest to the central cusp are considerably smaller and sometimes hardly visible.

These specimens cannot be assigned with certainty to any of the tropical species described under the names of *Cuthona* and *Cratena*, and most of these must be regarded as merely provisional. In describing small Aeolids of inconspicuous colouration and without any very salient characteristics, it is particularly desirable to examine a large series of specimens and ascertain what variations occur in the size and markings of the body and in the details of the teeth. But unfortunately there is rarely sufficient material for such an examination and it is consequently difficult to say whether the characters considered as specific really have such importance.

The present species is certainly distinct from *C. annandalei* described by me in the *Records of the Indian Museum* (vol. V, 1910, p. 248) but it is remarkable that both were found in brackish water and feeding on similar hydroids (*Bimeria*). For the name of the genus see my Supplement to Alder and Hancock's Nudibranchs, p. 129. I do not think that the genera *Cuthona* and *Cratena* can be maintained as distinct and *Cuthona* is the older name.

Elysia chilkensis, sp. nov.

The notes on the living animal are as follows:—

"A single specimen taken among weeds in a few inches of water close to the shore at Mahosa in the outer channel of the Chilka Lake, 20-iii-1914.

Form of body elongate and narrow, pointed behind but not produced. Tentacles very slender, tapering, pointed.

Colouration:—Dorsal surface dull moss-green marbled with a darker shade and dotted with white. Front of head between tentacles brownish, the brownish shade gradually diappearing behind head on sides of body. A colourless streak along the mid-dorsal line behind the head; a broad dark brown bar along each side of the head interrupted by a whitish streak containing the orifice of the tentacle.[1] Ventral surface greenish.

Specific gravity of water (corrected to 15°C) 1·0260."

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[1] If this implies that the tentacle is retractile it is probably a mistake.

The preserved specimen is 17 mm. long and of a uniform brown colour. The shape is as described in the above notes. The rhinophores are very distinct. They would be about 7 mm. long if straightened out, but are curved backwards into a crescent shape and still remain remarkably tapering and pointed. Their surface is smooth and under a lens presents no sign of a fold, but a section seen under the microscope shows a shallow groove. But in life the organs can hardly have been auriform as in most *Elysiae.* The wings are narrow and erect and the veins or ridges on their inner sides are prominent and conspicuous. The pericardial prominence is large and distinct. It it somewhat distorted as preserved, but its natural shape was probably oval. The external orifices appear to be placed as in *E. viridis*, but are not easily seen. The foot is long, distinct and bipartite, the anterior portion being marked off distinctly from the rest.

The radula is of the type usual in the genus and contains 8 teeth in the ascending part, 16 in the descending part and 5 in the heap. The teeth resemble those of *Elysia faustula* as described and figured by Bergh in his Malacogische Untersuchungen (in Semper's *Reisen*, Heft IV, pl. xxii, figs. 15-17. *Cf.* Eliot in *Proc. Zool Soc. London*, 1904, p. 295). They are dagger-shaped, rather elongate and there are no signs of denticulation on the lower edge.

This animal is in most respects a typical *Elysia*, but it has long, tapering tentacles which appear to be only slightly grooved, whereas in most species the tentacles are rather short and distinctly folded or auriculate. *E. lobata*, Gould, from Honolulu, *E.* (*Actaeon*) *australis*, Q. and G. and *E. coodgeensis*, Angas, both from Port Jackson, Australia, and *E. viridissima*, Trinchese, from the Mediterranean are all said to have long tentacles and the present specimen is very likely identical with one of them. But in colour it does not agree with any of them. This is not an important discrepancy for colouration is extremely variable in this genus, coloured borders and spots being present or absent in otherwise similar specimens. Still in the absence of any agreement as to colour it is impossible to identify our specimen with any of those known by the somewhat meagre descriptions of the authors mentioned above and it must be regarded provisionally as a new species, *Elysia chilkensis.*

FAUNA OF THE CHILKA LAKE

STAGES IN THE LIFE HISTORY OF *GOBIUS, PETROSCIRTES* AND *HEMIRHAMPHUS*.

By D. R. BHATTACHARYA, *M.Sc., Professor, Muir Central College, Allahabad.*

(Plates XVII—XVIII.)

CONTENTS.

STAGES IN THE LIFE HISTORY OF *GOBIUS*, *PETROSCIRTES* AND *HEMIRHAMPHUS*.

By D. R. BHATTACHARYA.

This paper deals with early stages in the life history of *Gobius ostreicola*, Chaudhuri, *Petroscirtes bhattacharyae*, Chaudhuri, and *Hemirhamphus limbatus*, Cuv. and Val. The specimens were all collected in the Chilka Lake by members of the staff of the Indian Museum. I worked on the first two above-mentioned species in the months of May and June, 1915, in the Indian Museum at Calcutta. The specimens of the third were sent to me here at Allahabad, and I worked them out in the Biological laboratory of the Muir Central College, during the month of August, 1915. As it was too hot then for microtome work, many features of the internal anatomy have been neglected, and the paper naturally is not supposed to be exhaustive.

My sincere thanks are due to Dr. Annandale, Superintendent of the Indian Museum, and to Dr. Chaudhuri, Assistant Superintendent, Indian Museum, for kindly allowing me to work in the Museum laboratory, for placing the collections of the Chilka Lake Survey at my disposal, and for assisting me in many other ways, especially in looking up literature on the subject.

Gobius ostreicola, Chaudhuri.

(Plate XVII, figs. 1—7.)

1916. *Gobius ostreicola*, Chaudhuri, *Rec. Ind. Mus.*, XII, p. 105.

The specimens were collected on the oyster-beds of Manikpatna in the outer channel of the Chilka Lake during the first week of December, 1914. The water at that place was then almost fresh owing to the floods at the close of the monsoon, though later on in the dry season the water becomes as saline as in the Bay of Bengal. The specific gravity of the water was found to be 1·01250.

The egg is elongated and oval in shape with a bunch of filaments at the distal extremity which serves as a means of attachment to foreign bodies. In this case the eggs were found attached to the concave side of a dead oyster shell measuring about $3\frac{1}{2}$ inches in length and $2\frac{1}{2}$ inches in breadth. On a rough calculation about 400 eggs were found covering a surface of one sq. cm. The method of attachment of the eggs to the shell is very characteristic There springs from the pedicle of the egg a hyaline structure which spreads out like an umbrella and ends in viscid thread-like filaments which adhere to the shell or to the filaments of the adjacent ova. This hyaline structure is traversed by alternate rows of oval apertures which gradually become bigger in size distally. Three or four such concentric rows of apertures may be made

out under the high power of the microscope. The apertures in the last row (distally) do not keep an exactly oval shape, but are generally slightly curved or bent and much more elongated than broad.

The egg shown in pl. xvii, fig. 1 was the smallest of the lot I came across and measures ·5 mm. in length. It is in one of the early stages of development. Numerous small globules, very likely oil globules, may be seen in the yolk-mass. The egg-membrane is more or less closely attached to the developing egg. The examination of the contents of the egg seems to show, however, that it is really a degenerate egg.

The egg in pl. xvii, fig. 2 measures 1·6 mm. in length. Intermediate stages between figures 1 and 2 could not be found. At this stage the embryo is fairly well developed. In a lateral view the eye, ear and heart may be seen to have begun to develop. The eye has not yet acquired pigments and is consequently colourless. The ear is a simple pit-like depression. The heart is represented by a very minute sac-like dilatation. The yolk-mass lies in a yolk-sac on the ventral surface of the body. Immediately above the yolk-mass we see the beginning of the notochord which gradually tapers towards the tail end, though it has not yet reached its extremity. On the dorsal surface of the embryo from the anterior end to about the middle of the body a thickening like that of the neural plate is observable. It marks the beginning of the development of the nervous system. A continuous fin-fold all over the body, except for a small portion of the head-end of the embryo, forms one of the most characteristic features of the embryo at this stage.

Plate xvii, fig. 3 shows an empty egg-membrane from which the embryo has been extruded. The wavy line at the upper end marks the point of rupture during extrusion.

The specimen in pl. xvii, fig. 4 measures 2 mm. At this stage we find the nervous system fairly well developed. The notochord reaches the extremity of the tail and is slightly curved upwards (heterocercal), and the caudal fin-fold acquires a corresponding shape. The epichordal lobe becomes reduced in size and the hypochordal lobe becomes comparatively enlarged. The continuity of the fin-fold is more or less broken near the middle of the body by its extreme narrowness, and we get anteriorly a dorsal fin-fold, posteriorly a caudal fin-fold, and ventrally a pre-anal fin-fold. The transition from fig. 2 to fig. 5 is rather abrupt. A truly heterocercal stage is not visible and we apparently get a homocercal (fig. 7) from a diphycercal (fig. 2) type. Fig. 5, however, approaches the heterocercal stage to some extent. Black stellate chromatophores lie in streaks both above and below the notochord, but do not reach the caudal extremity. The anus lies near the middle of the body, but the anterior portion of the alimentary canal is either undeveloped or indistinct. The heart acquires a coiled shape.

Plate xvii, fig. 6 shows a slightly more advanced stage. It has a curved tail, which is of course not a characteristic feature of this stage, for many specimens of earlier stages possess coiled or curved tails. This stage marks the development of pectoral fins and of another stucture—probably the gas-bladder which lies just in front of the yolk-mass.

Plate xvii, fig. 7 is the most developed of the specimens which I have seen. It is not yet hatched, but in all likelihood is just ready to be hatched. Of course, hatched specimens leave the colony and lead independent lives and that is why I have not come across them. At this stage the eyes become quite prominent and acquire pigments. The pupil looks yellowish-grey with a brownish spot in the middle, and the bulk of the eye looks brownish-black under the high power of the microscope. The yolk-mass gradually decreases in size. Two streaks of black (in places brownish) resembling stellate chromatophores may be seen lying dorso-laterally, one on either side of the notochord. A big chromatophore lies just in front of the yolk-mass. Embryonic fin-rays may be seen under the high power in the homocercal (not yet true homocercy) caudal fin. The embryonic dorsal fin also becomes well developed. No pigments have been found to occur in the embryonic fins. The pelvic fin has not as yet made its appearance. The pectoral fins are well developed and become fan-shaped. The transparency of the body is lost and every preparation to reach the adult form is more or less begun.

Petroscirtes bhattacharyae, Chaudhuri.

(Plate XVII, figs. 8—11.)

1916. *Petroscirtes bhattacharyae*, Chaudhuri, *Rec. Ind. Mus.*, XII, p. 107.

This species is believed to be a new one and no description of its larval stages seems to exist. Some specimens were obtained off Balugaon on 6-iii-1914, and others near Barkuda I. on 19-xi-1914. The specific gravity of the water (corrected to a standard temperature of 15°C) was about 1·007 on the former occasion and about 1·006 on the latter, showing a low salinity on both.

Only three distinct stages are available. The smallest specimen found measured 3·25 mm. in length and the largest specimen 15·9 mm. (including the middle caudal fin-rays). The following table gives the measurements in mm. of (1) the smallest, (2) the next higher stage—I shall call it medium for the sake of convenience, and (3) the largest specimens available.

Stage.	Total length.	Depth of body.	Length of caudal fin.	Length of pectoral fin	Length of spine.	Length of head.	Length of pelvic fin.
I. Smallest ..	3·25	·6	No distinct caudal fin.	·5	·3	·8	Not yet developed.
II. Medium ..	13·25	2·25	1·8	2·5	1·25	2·5	1·75
III. Largest ..	15·9	2·7	2·1	3·25	1·8	3	2·25

The specimen shown in pl. xvii, fig. 8 measures 3·25 mm. in length (stage I). The muscle segments are fairly well developed and are about 34 in number, out of which about 24 can be distinctly made out, the myocommas of the most anterior and the most posterior segments being rather indistinct. The myotomes have not yet quite acquired the shape of the adult and are slightly wavy in character.

The "concentration" of the body segments has not yet taken place except at the anterior end.

The dorsal, caudal, and anal fin-folds are continuous (a primitive character). Furthermore, the skeletal supports of the fin-folds are either not yet developed or if developed (there are faint indications of the development of the fin-rays towards the caudal end) are not visible even under the high power of the microscope. The pelvic or ventral fins are not yet developed. The pectorals are short and contain 9 fin-rays.

The pigments are a characteristic feature of the larva. There are eleven fairly big black stellate chromatophores in the anal fin-fold from about the middle of the body to the base of the caudal fin-fold. There are also scattered but rare small brown (or in places blue black) pigment spots both in the dorsal and anal fin-folds. The caudal fin-fold is practically free from pigments. At the distal extremity of the pectoral fin beginning from about the middle, pigments of a deep blue black colour are very densely situated.

The posterior region of the alimentary canal and anus are visible. A short opercular spine and a frontal protuberance are developed. The notochord is well developed and extends to the tip of the tail end.

Slightly older stages than these are available. They show a slightly heterocercal tail fin. The caudal fin-rays in these have just begun to develop, but are not yet segmented. In the anal fin-fold the number of chromatophores varies from 12-15 in number.

Plate xvii, fig. 9 (stage II) measures 13·25 mm. in length (including the middle caudal fin-rays). This is a much more advanced stage than fig. 8. The myotomes are well developed, and the myocommas are quite distinct. The longitudinal horizontal septum separates the epiaxial from the hypaxial portion of muscle segments.

The fin-folds have become discontinuous and we get a long dorsal, a caudal, and a long anal fin. The diphycercal and heterocercal stages have been passed through, and we get the homocercal type of fin characteristic of the adult. The caudal fin consists of 22 jointed fin-rays and is practically free from pigments. The ventral fin is short and slender and lies anterior to the pectorals on the ventral side of the body. It consists of 2 fin-rays only. The pectorals are composed of 13 fin-rays, and are deeply pigmented (blue black) towards the distal end. The dorsal and anal fins are composed of spinous rays which will be described in detail in the next stage. On each side of the dorsal and anal fins, and closely attached to them is a membranous fin-fold in which lie a row of pigments or chromatophores (fig. 9 *i*). The stellate chromatophores of fig. 8 are lost at this stage.

The frontal prominence and narial tentacles are developed. The eyes are well developed and acquire deep pigments. Two (only) opercular spines, one on each side of the body, are developed, their extremities having a curiously bent shape. Whether this is their natural condition or is due to injury (which seems more likely), I cannot say, but all the available medium-sized and large specimens (6 only in number) showed this bent condition. The pigments of the brain are visible dorsally through the cartilaginous cranium and the various elements which compose the adult skull are as

yet imperfectly developed. The operculum is fairly well developed and the gills may be easily made out under the microscope. The mouth is armed with sharp pointed teeth.

Plate xvii, fig. 10 (stage III) measures 15·9 mm. in total length (inclusive of the middle caudal rays). The myotomes are well developed. As far as could be made out under the microscope there are about 42 myotomes on each side of the body. The "concentration" of muscle segments must have taken place in the region of the paired fins, and in the most anterior and posterior regions of the body, but throughout its greater length the correspondence between muscle segments, radial muscles, unjointed fins or spines, and the superficially segmented dorso-lateral and ventro-lateral dorsal and anal fin-folds respectively—as I propose to call them—is very remarkable. A reference to figures 9, 10 and 11 will show that on each side of the dorsal and anal fins there is a membranous superficially segmented fin-fold containing towards the distal end a number of black pigment spots or chromatophores. These membranous fin-folds are devoid of spines (fig. 11*e*), and their segmented portions or processes are very short, flat and blunt. The dorsal fin consists of the conical muscle processes at the base, from the apex of which (I could not see any close connection between the two) arise unjointed rays or spines (fig. 11). A muscle segment or myotome corresponds with a radial muscle process, a spine, and a segment of the dorso-lateral membranous fin-fold on each side. This correspondence even in the post-larval stage lends support to the theory of segmentation in vertebrates. Certainly later on during development this arrangement undergoes a great deal of modification so essential to keep up the rigidity of the body in order to keep pace with the growingly active movements of the animal. The conical muscle prominences, which in all probability are radial fin muscles, seem to hide from view the corresponding radialia or somactidia, for they are not visible anywhere even under the high power of the microscope. These conical prominences are not yet separated from the myotomes from which they are developed.

A comparison with the *Petroscirtes* species juv. described by Max Weber in *Die Fische der Siboga Expedition*, published in Leiden, 1913, will show certain striking differences. Max Weber describes in his specimens the dorso-lateral folds as being provided with elongated spine-like processes, but in my specimens the processes are very short, flat and blunt. Again he shows only one pigment spot (which is comparatively bigger) in each segment of the anal fin close to the base of the spine, but in my specimens a number of comparatively smaller pigment spots lie more or less in a row not at the base of the anal fin, but at the apex of each dorso-lateral and ventro-lateral fin-fold segment. Again he shows the pigments only in the anal fin, but in my specimens they occur both in the dorso-lateral and ventro-lateral fin-folds in the same positions. He also shows a number of smaller spines in the operculum, which are absent from my specimens. These differences provide ample evidence to prove that my specimens belong to a different species to that described by Max Weber.

The caudal fin is composed of 24 jointed fin-rays. The pectoral and ventral fins are fairly well developed, the former being deeply pigmented towards the distal end. The opercular spine, eyes, and mouth are well developed. A short, blunt and flat

protuberance lies in front of the head above the mouth which I have called the frontal prominence. The mouth is provided with fairly well developed pointed teeth. Later post-larval stages would have shown interesting developments but unfortunately we have not got them.

Hemirhamphus limbatus, Cuv. and Val.

(Plate XVIII, figs. 1—6.)

Young stages of this species were taken in all parts of the Chilka Lake in fresh as well as in brackish water.

Some of the specimens in this collection do not seem to have been well preserved. However, a fairly gradual series of larval stages have been found, and the collection therefore is interesting. I have sorted out the specimens and divided them into 13 distinct stages. Some of the specimens were stained with Borax Carmine, and others with methylene blue. The latter brings certain structures, *e.g.*, cartilaginous skeleton and chromatophores, prominently into view and allows them to be traced for greater distances than the former does. But, on the whole, I found specimens stained with Borax Carmine more suitable for descriptive purposes. The accompanying table shows the length in mm. of body, snout and gas-bladder of the 13 larval stages I am going to describe.

Stage.	Length of body including snout and tail fin.	Length of snout.	Length of gas-bladder.	REMARKS.
I	2·5	·0841	?	Specimen not well preserved.
II	2·75	·1069	·1662	
III	3	·1187	·2375	
IV	3·75	·1306	·5770	Fin-fold still continuous, but slightly constricted towards tail.
V	6	·1425	3	More or less distinct tail fin: fin-fold still slightly continuous.
VI	6·75	·1544	3·125	
VII	7·5	·1781	3·5	
VIII	8	·1900	3·75	
IX	8·5	·2109	4	
X	10	·2375	4·5	
XI	10·5	·2612	5	
XII	11	·2850	5·25	
XIII	12	·3444	5·75	A young fish.

STAGE I. This is the smallest specimen I have come across. It measures 2·5 mm. in length. I have not sketched it, as the poor fixation of this specimen makes it difficult to determine the details of internal anatomy with any degree of accuracy. The eye and the gas-bladder is already formed. The lower jaw is prolonged into a slender beak. On the ventral surface a big chromatophore is present (see pl. xviii, fig. 1). The dorsal surface of the gas-bladder is pigmented. The tail is protocercal.

STAGE II. This specimen measures 2·75 mm. in length. The beak or snout becomes slightly more elongated and distinctly pronounced at this stage. The same chromatophore is present on the ventral surface. The tail begins to assume the heterocercal type, and the notochord and myotomes become fairly distinct. The cartilaginous development of the skull and visceral arch has begun. The cartilage cells are quite distinct.

STAGE III (pl. xviii, figs. 1 and 2). The eye is well developed and looks like an opaque black mass. Dorso-ventrally it is longer than laterally. The beak is curiously shaped, being bent in front like that of some birds. The visceral arches are well developed. Under the high power of the microscope, the visceral arches are seen to be lined by more or less parallel rows of cartilage cells. The heart lies just below and behind the basibranchial cartilage, and is in a fairly advanced stage of development. The various chambers are however just formed, and their connections and the various blood vessels which they give rise to are quite indistinct. The gas-bladder has an oval shape and is invested dorsally with pigment bodies. It is continued anteriorly into a hollow tube-like structure which seems to open just at the junction of the pharynx with the oesophagus. The notochord is well developed, and bends sharply upwards at the caudal end to form the beginning of the heterocercal type of tail fin. The myotomes and myocommas are developed, but the body is still more or less transparent. The alimentary canal is formed, but its different regions are rather indistinct. It lies close beneath the gas-bladder. Posteriorly it opens by the anal aperture. The glandular epithelium lining the internal cavity of the stomach is visible under the high power of the microscope, but the cavity of the stomach is very narrow. The spinal cord lies just above the notochord. The brain is also formed, but its various regions are indistinct. The liver is also formed and lies beneath the oesophagus and the anterior region of the stomach. It becomes more distinct in the next stage. The big stellate chromatophore still persists on the ventral side of the body. Except for this one, and those in the gas-bladder, no other chromatophores are to be seen in the body. The dorsal, ventral, and caudal fin-folds are still continuous and quite distinct.

STAGE IV (pl. xviii, fig. 3). The specimen has been sketched exactly as it was found with the mouth wide open. It gives a good idea of the relation of the upper and lower jaws The cartilage cells are very numerous and prominent at this stage. The mandibular, hyoid, and branchial arches are all well developed. The last branchial arch is rather indistinct. Rows of papilla-like outgrowths appear on the first 4 branchial arches, those of the first 3 being quite prominent. These seem to be the rudiments of the branchiae. The opercular membrane also makes its appearance.

The hyoid arch has a curved shape, and the arches of both sides meet ventrally. At their point of junction is to be seen a small cartilaginous piece (probably basihyal) projected forwards,—its hinder portion meeting the anterior prolongation of the basibranchial. The various divisions of the arches are not yet differentiated. The cartilaginous cranium is formed and is still more or less transparent. The heart may be faintly made out, as before, beneath and behind the basibranchial cartilage. The gas-bladder takes an elongated shape, and its dorsal surface is deeply pigmented black. Its anterior prolongation becomes indistinct, but its posterior prolongation is quite distinct, and it seems to open just behind the anus by a distinct slit. The notochord is well developed, and is constricted off into a number of pieces, to form the beginning of the future vertebral column. The skeletogenous layer has started its work, and the skeletogenous cells may be seen in large numbers just at the base and above the notochord. In the latter place they are quite abundant, and may be seen to enclose the spinal cord. The heterocercal tail is fairly well developed, but the fin-rays have not yet made their appearance. The myotomes are well developed, and the transparency of the body is still to a large extent retained. The alimentary canal seems in some places to consist of a solid cord of cells, and the cavity is obliterated, but this may be due to external causes.

The liver may be seen as a thick mass of cells, in front of the stomach. The big stellate chromatophore still persists, though it is now much reduced in size. In addition to it, a number of small chromatophores (about 16) make their appearance on the ventral side of the body. The fin-folds are still continuous, though much norrowed towards the caudal end.

STAGE V (pl. xviii, fig. 4). This stage is much more advanced than stage IV. The intermediate stages which would have been very interesting are missing. The snout or beak does not seem to have kept pace with the enormous increase in the length of the body. In fact, I tried to establish a ratio between the length of increase of the body, the gas-bladder and the beak, but failed hopelessly. The above table (p. 388) will show that the increase in the length of the beak has no relation whatsoever with the development of the body.

The operculum is well developed and the branchial arches can only be indistinctly made out. The papilla-like outgrowths have reached a considerable size and are quite a characteristic feature of this stage. The cranium is fairly well developed, and its transparency is lost. The gas-bladder has kept pace with the increase in length of the body and the same is the case with the alimentary canal. The position of the gas-bladder in the body is now denoted only by a long series of deeply pigmented bodies close beneath the notochord. On a careful examination under the high power of the microscope a dense network of capillaries may be seen lining the walls of the gas-bladder. These capillaries probably form the "retia mirabilia" or "red bodies" of the adult. They are arranged in fan-like tufts over almost the whole extent of the inner surface of the gas-bladder. Owing to the opacity of the body the notochord is not distinctly visible, but it is being gradually enveloped by the skeletogenous cells to form the future vertebral column. The condition of the tail is midway between

the heterocercal and homocercal type—a rather nearer approach to the latter. The caudal fin-rays are quite distinct.

The gradual growth of the myotomes has increased the opacity of the body. The chromatophores of the last stage have all disappeared, except of course those of the gas-bladder. In their place we find a paired ventral row of chromatophores, which probably become attached together and form a continuous streak between the anus and the caudal fin. A middle paired row (one on either side of the body) consisting of about 24 chromatophores, occurs on the sides of the body and in a lateral view seems to lie over the notochord. A dorsal paired row lies on the dorsal surface of the body. Each row consists of 16 distinct anteriorly situated chromatophores, and a continuous streak posteriorly consisting of about 9 chromatophores. Pigment spots also make their appearance in the upper jaw. Large irregular pigment bodies are to be seen on the dorsal and lateral sides of the head. They are irregular in their distribution (not shown in the figure). Ventrally in the anterior region of the trunk close behind the head, a line of small black pigment spots make their appearance. The dorsal and ventral fin-folds still exist, though in a much more modified form. The dorsal and anal fins are developed, but their skeletal structures are not yet visible.

Stage VI (pl. xviii, fig. 5). There is not much difference between this stage and the previous one. The snout in particular shows very little increase, while the general increase in length is ·75 mm. The bony framework of the skull is developing fast and the head region has become quite opaque except on the ventro-lateral edge, where the branchiae are just visible through the operculum. The gas-bladder becomes more densely pigmented. All the 3 paired rows of pigments described in the previous stage are present. The pigments in the head region are repeated again as in the previous stage, except that now the beak also acquires pigments.

The tail acquires true homocercy. The caudal fin-rays are well developed, and faint traces of segmentation are visible in it. The myotomes have considerably grown in thickness and nearly completely hide the notochord from view. There are about 45 myotomes of which 40 are quite distinct. The dorsal and anal fins are fairly well developed and their skeletal structures are also visible. Very faint traces of them were really found in the previous stage. A careful examination under the high power of the microscope reveals the presence of pterygiophores (Parker) or radial elements (Bridge). Corresponding to each fin-ray there is a baseost and an axonost (Cope), the former lying between the heads of two adjacent axonosts as a small round body. The ventral fin-fold still persists, though the dorsal fin-fold disappears. Another striking feature is the appearance of the pectoral fin close behind the operculum.

Stage VII. The general pigmentation of the body is the same as in the previous stage. The pigments in both the upper and lower jaws and the head are better developed than in stage VI. The fins are pigmented.

Stages VIII, IX, X, XI, and XII. These stages are marked by the gradual growth of the body, beak, and gas-bladder. The pigmentation is practically the same as in stage VII. A gradual growth of the gills, the bones of the skull, and the

skeletal structures of the pectoral, caudal, dorsal, and ventral fins takes place. The ventral fin-fold persists, and the pelvic fin has not yet made its appearance.

Stage XIII (pl. xviii, fig. 6). The specimen measures 12 mm. in length. The myotomes are fully developed, and more or less completely hide from view the organs inside the body. The prolongation of the lower jaw as snout or beak becomes quite a prominent feature, being just over $\frac{1}{3}$ of a mm. in length. The pelvic fin makes its appearance for the first time. The dorsal and anal fin-rays are well developed. The dorsal fin contains 11 distinct and 2 or 3 indistinct fin-rays. The anal fin contains 14 distinct fin-rays. The ventral fin-fold still persists though faintly, but seems to be interrupted or folded up in the region of the pelvic or ventral fin. The animal is now really a young fish in nearly all respects, and thus marks the termination of the larval stage.

EXPLANATION OF PLATE XVII.

Gobius ostreicola, Chaudhuri.

FIG. 1.—Ovum attached to a dead Oyster shell.

,, 2.—Lateral view of the embryo, inside the egg-membrane.
a=eye; *b*=continuous fin; *c*=notochord; *d*=ear; *e*=beginning of nervous system; *f*=heart; *g*=egg-membrane; *h*=pedicle; *i*=filaments; *j*=yolk.

,, 3.—An empty egg-membrane attached to the shell by means of filaments.

,, 4.—Ventral view of an embryo slightly older than the one seen in fig. 2.

,, 5.—Lateral view of the embryo, showing a heterocercal tail.
a=heart; *b*=two streaks of chromatophores lying above and beneath the notochord; *c*=posterior portion of the notochord; *d*=yolk; *e*=eye; *f*=pre-anal fin; *g*=anus.

,, 6.—Dorsal view of a slightly older embryo.
a=gas-bladder; *b*=pectoral fin; *c*=tail curved; *d*=yolk.

,, 7.—Dorsal view (diagrammatic).
a=pectoral fin (fan-shaped); *b*=two streaks of chromatophores; *c*=caudal fin; *d*=dorsal fin; *e*=chromatophore; *f*=gas-bladder.

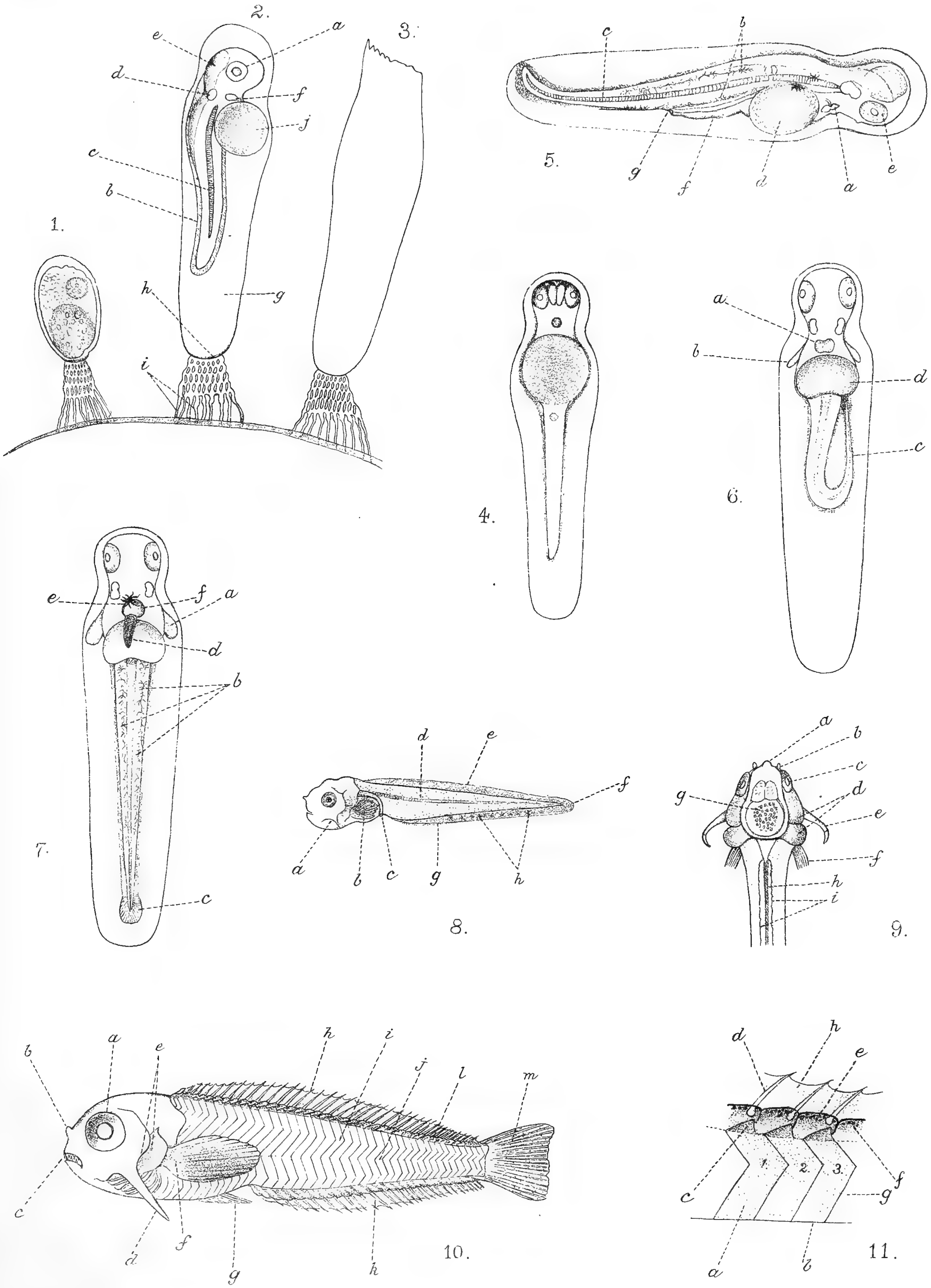
Petroscirtes bhattacharyae, Chaudhuri.

FIG. 8.—Lateral view of the smallest specimen at stage I.
a=opercular spine; *b*=pectoral fin; *c*=anus; *d*=notochord; *e*=dorsal fin-fold; *f*=caudal fin-fold; *g*=ventral fin-fold; *h*=chromatophores.

,, 9.—Dorsal view of the medium-sized specimen at stage II.
a=frontal prominence; *b*=narial tentacles; *c*=eye; *d*=operculum; *e*=opercular spine; *f*=pectoral fin; *g*=brain; *h*=dorsal fin; *i*=dorso-lateral (paired) membranous fin-fold.

,, 10.—Lateral view of the largest specimen at stage III.
a=eye; *b*=frontal prominence; *c*=mouth; *d*=opercular spine; *e*=operculum; *f*=pectoral fin; *g*=pelvic (ventral) fin; *h*=dorsal fin; *i*=myotome; *j*=longitudinal horizontal septum; *k*=anal fin; *l*=dorso-lateral membranous fin-fold; *m*=caudal fin.

,, 11.—A portion of the dorsal fin with its left membranous fin-fold.
a=myotome; *b*=longitudinal horizontal septum; *c*=conical muscular process; *d*=spine (unsegmented fin-ray); *e*=left membranous fin-fold; *f*=pigments; *g*=epiaxial portions of myotomes; *h*=dorsal fin.



D.R.B. del. A. Chowdhary, lith.

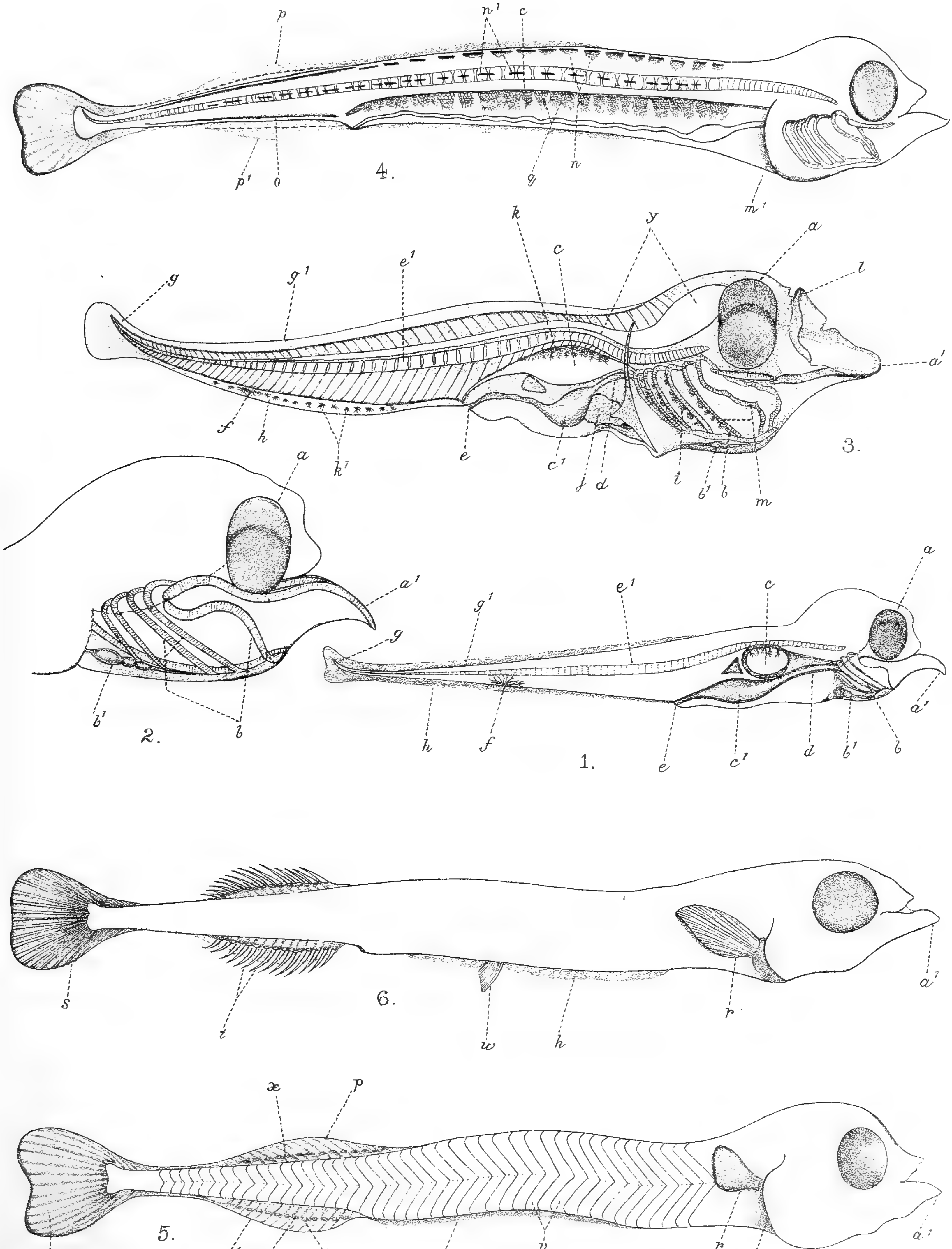
EXPLANATION OF PLATE XVIII.

Hemiramphus limbatus, Cuv. and Val.

FIG. 1.—An outline of the larva at stage III, × 40.
,, 2.—The head region of the larva showing the development of the visceral arches, × 80.
,, 3.—The larva at stage IV, × 40.
,, 4.—The larva at stage V, × 30.
,, 5.—The larva at stage VI, × 30.
,, 6.—A young fish at stage XIII, × 20.

EXPLANATION OF LETTERING.

a = eye; *a′* = beak; *b* = visceral arch; *b′* = heart; *c* = gas-bladder; *c′* = stomach; *d* = oesophagus; *e* = anus; *e′* = notochord; *f* = chromatophore (big); *g* = caudal fin; *g′* = dorsal fin-fold; *h* = ventral fin-fold; *i* = rudiments of branchiae; *j* = liver; *k* = chromatophores in gas-bladder; *k′* = chromatophores (small); *l* = upper jaw; *m* = parallel rows of cartilage cells; *m′* = operculum; *n* = dorsal row of chromatophores; *n′* = middle row of chromatophores; *o* = ventral row of chromatophores; *p* = dorsal fin; *p′* = anal fin; *q* = retia mirabilia; *r* = pectoral fin; *s* = caudal fin: *t* = fin-ray; *u* = baseost; *v* = myotomes; *w* = pelvic or ventral fin; *x* = axonost; *y* = brain and spinal cord.



D.R.B. del. A. Chowdhary, lith.

FAUNA OF THE CHILKA LAKE

CUMACEA.

By STANLEY KEMP, *B.A.*

(With 5 text-figures.)

CONTENTS.

CUMACEA.

By Stanley Kemp.

The Cumacea found in the Chilka Lake belong to two species both of which appear to be undescribed. They belong respectively to the genus *Iphinöe* of the family Bodotriidae and to *Paradiastylis* of the family Diastylidae. No species of either of these genera has hitherto been recorded from brackish water and the group as a whole is essentially marine in habitat.

The *Iphinöe* was found only in the main area of the lake. It occurred rarely in March in water of specific gravity 1·008, but was taken in abundance later in the year in water that was almost or quite fresh. Only females of this species were discovered.

The *Paradiastylis* was common in the main area of the lake at all times of the year and, in the freshwater season, was found in the outer channel. The species is evidently able to thrive in water varying in specific gravity from 1·000 to 1·015.

Family BODOTRIIDAE.

Genus **IPHINÖE**, Bate.

Iphinöe sanguinea, sp. nov.

Of this species females only were obtained.

The carapace, including the pseudorostral lobes, is about two-sevenths the total length, excluding uropods. The depth of the carapace is a little more than half its length. The pseudorostral lobes are scarcely upturned; they are apically pointed and the margin of each, below the apex, is obliquely truncate—slightly concave anteriorly and a little convex in advance of the exceedingly shallow antennal notch. The convexity bears a series of about five small forwardly-directed teeth and further back, behind the insertion of the antennae, there is a series of some twenty similar teeth on the anterior half of the lower margin of the carapace (text-fig. 2 *a*). There is no antennal tooth. The carapace is feebly carinate in the median line for a short distance behind the eye, the carina bearing five (more rarely four) small forwardly-directed teeth. The teeth are situated well in advance of the middle point of the carapace, differing conspicuously in position from those found in the Atlantic *I. trispinosa*. The carapace is otherwise devoid of sculpture, but is closely covered with a very fine reticulation, only visible under high powers of the microscope.

The first pedigerous somite is well exposed both dorsally and laterally and is not, as in *I. trispinosa*, covered at the sides by a forward prolongation of the second somite. The second somite, measured dorsally, is about one and a half times the length

of the first; the third and fourth are about equal, intermediate in length between the first and second. Except for the first, the somites are a little puckered laterally, but are otherwise without sculpture. On either side of the last three somites, near the anterior margin, is a large forwardly-directed bristle which does not seem to occur in any other species of the genus (text-figs. 1 *a*, *b*).

The abdominal segments are without carinae. In lateral view each is strongly convex ventrally in its anterior half.

In the peduncle of the first antennae (text-fig. 2 *b*) the third segment is longer than the second. At the distal end of the third segment are a few simple hairs, while in a similar situation on the first and second segments are others of a more complex nature which are illustrated in detail in text-figs. 2 *c*, *d*. The inner flagel-

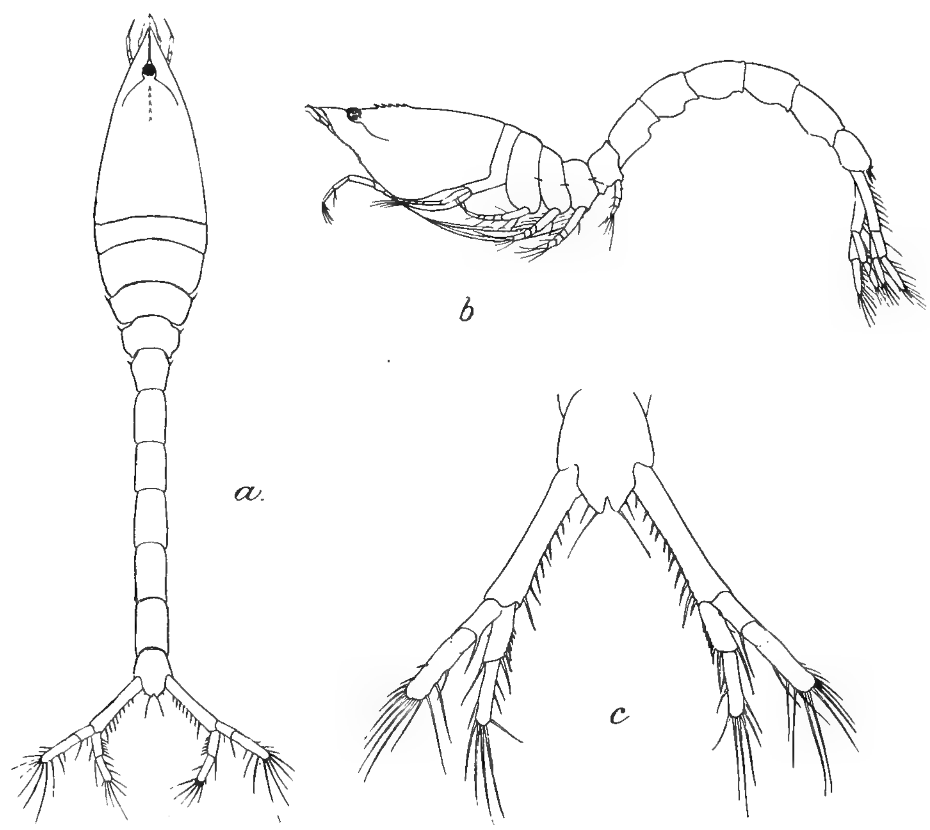


FIG. 1.—*Iphinöe sanguinea*, sp. nov. ♀.

a. Female in dorsal view. *b*. Female in lateral view. *c*. Last abdominal segment and uropods.

lum is extremely small, but is two-segmented. The outer is also two-segmented and carries two long annulated filaments.

The second antennae (text-fig. 2 *b*) are very inconspicuous in the female and consist of two segments, the basal one subtriangular and the distal very slender and articulated with it at an acute angle. The distal segment bears a single long seta at its apex.

The form of the second maxillipedes is shown in text-fig. 2 *e*. In the third maxillipedes (text-fig. 2 *f*) the second segment is not much longer than the combined length of the segments distal to it. Externally the distal end of the second segment reaches a little beyond the articulation between the third and fourth; on its anterior margin is a series of six setae, the two outermost being of great length. The produced

end of the fourth segment reaches to the middle of the fifth and bears three setae externally.

In the first peraeopods (text-fig. 2 *g*) the second segment is a little shorter than the rest of the limb; its external margin is serrated near the base. The fifth segment is considerably longer than the sixth or seventh. The second peraeopods (text-fig. 2 *h*)

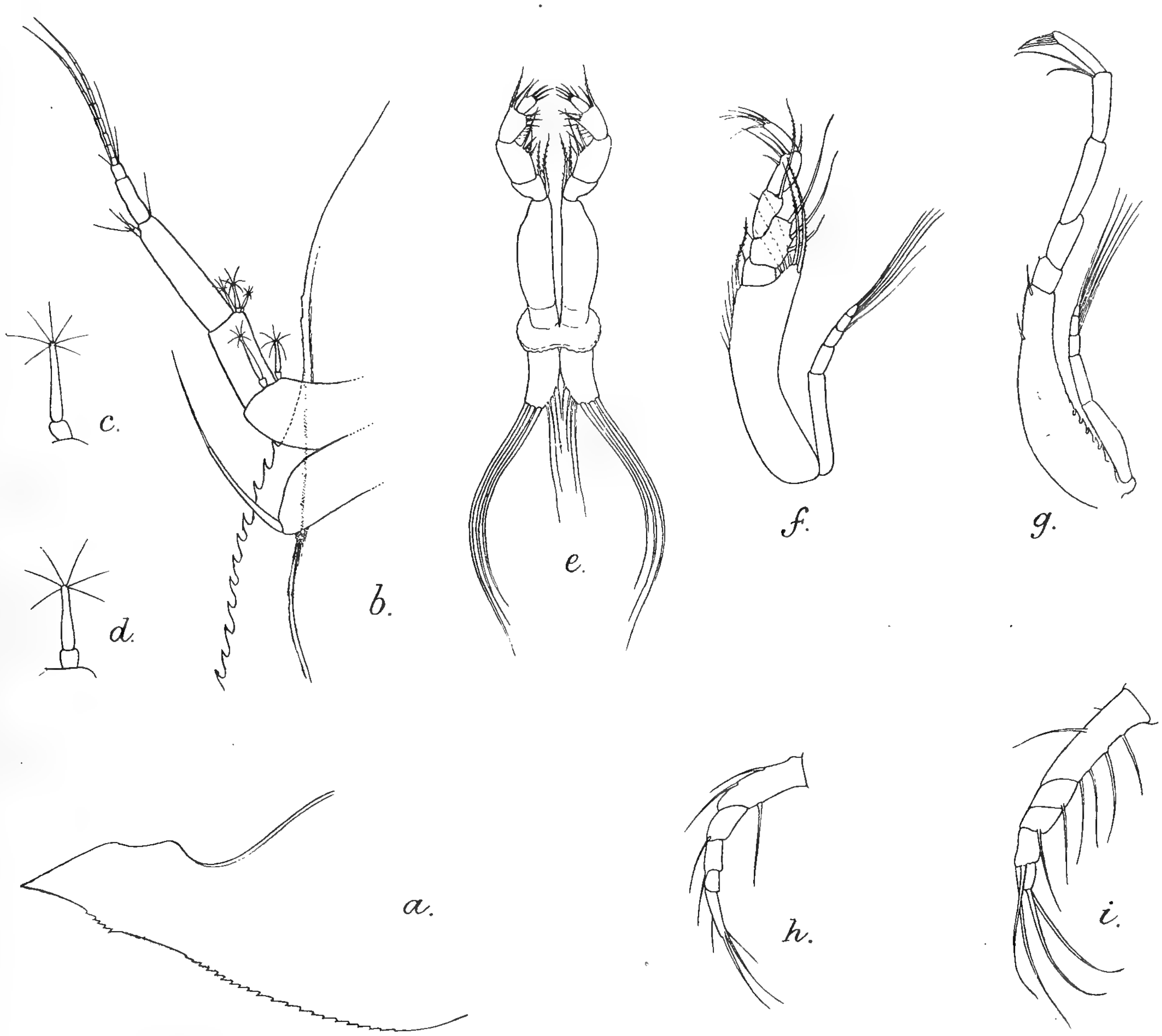


FIG. 2.—*Iphinöe sanguinea*, sp. nov. ♀.

a. Left pseudorostral lobe and adjacent part of carapace.
b. Antennule and antenna.
c, d. Hairs from peduncle of antennule.
e. Second maxillipedes.
f. Third maxillipede.
g. First peraeopod.
h. Second peraeopod.
i. Third peraepod.

are a little shorter than the third (text fig. 2 *i*); the ultimate segment of the former is slender and about as long as the two preceding combined.

The peduncle of the uropods (text-fig. 1 *c*) is about one quarter longer than the exopod or endopod, the two latter being subequal. On the inner margin of the peduncle there is a series of from 8 to 11 long spines. The exopod is composed of two segments. In dorsal view the ultimate is about twice the length of the penulti-

mate; the latter, however, is much produced inferiorly at its distal end and the two segments when seen from below are almost equal in length. The basal segment bears one or two setae internally and the distal some 11 or 12 distributed round its apex. Of the two segments that compose the endopod, the first is a little shorter than the second and is provided internally with a series of six or seven spines which are closely set and increase in size distally. There is also a single slender spine at the end of the outer margin. The ultimate segment bears five or six slender spines at its apex and one or two on the inner edge.

Large specimens reach a length of about 5 mm.

Stebbing in his monograph of the Cumacea[1] recognises eight species of *Iphinöe.* Of these the species from Lake Chilka is evidently most nearly allied to *I. trispinosa* (Goodsir), a species found in the N. E. Atlantic from an area ranging from the Bay of Biscay to the Shetland Is. and Norway. So far as females are concerned *I. sanguinea* is easily distinguished from this species by the number and disposition of the teeth in the mid-dorsal line of the carapace, by the teeth on the lower margin of the carapace, by the form of the second pedigerous somite which does not overlap the first, by the bristles on the last three of these somites and by a great number of details in the appendages.

Iphinöe sanguinea is, when living, of a deep blood-red colour, a feature to which allusion is made in the specific name. The species was only found twice in the Chilka Lake, firstly in March, when a few specimens were obtained in the vicinity of Kalidai in water of specific gravity 1·008 (corrected), and secondly in September, much further to the north, in water that was practically fresh. On the latter occasion large numbers of specimens were collected, all of them, however, females.

The absence of males is doubtless to be attributed to differences in habits between the two sexes. The examples obtained were all caught in nets fished on soft mud at depths of between 6 and 8 ft. The males are perhaps to be found at some distance above the bottom, but I have searched our townet gatherings for them without success. There can be little doubt that the species is a permanent inhabitant of the main area of the lake: there are embryos in the brood-pouches of some of the females caught in September.

The species of *Iphinöe* hitherto described are recorded from the Mediterranean and N. E. Atlantic, from the Gulf of Guinea and from S. Africa. One species is also known from the Gulf of Manaar.

Family DIASTYLIDAE.

Genus **PARADIASTYLIS,** Calman.

Paradiastylis culicoides, sp. nov.

This species is remarkable for the great differences that exist between the sexes in the form of the apex of the telson. In the female there are two minute terminal

[1] *Das Tierreich: Cumacea,* p. 42 (1913).

spines, whereas in the male the apex is drawn out to a long, sharp, spine-like process, in this respect disagreeing with the diagnosis of the Diastylidae in Stebbing's synopsis of the families of Cumacea.[1] The peculiar structure of the telson of the male may also be proper to some other species of the genus, for the sex is unknown in two out of the three species that have been described.

Female.—The carapace (text-figs. 3 *a*, *b*) is considerably inflated and its breadth is little less than one-third the total length, uropods excluded. The surface is rather

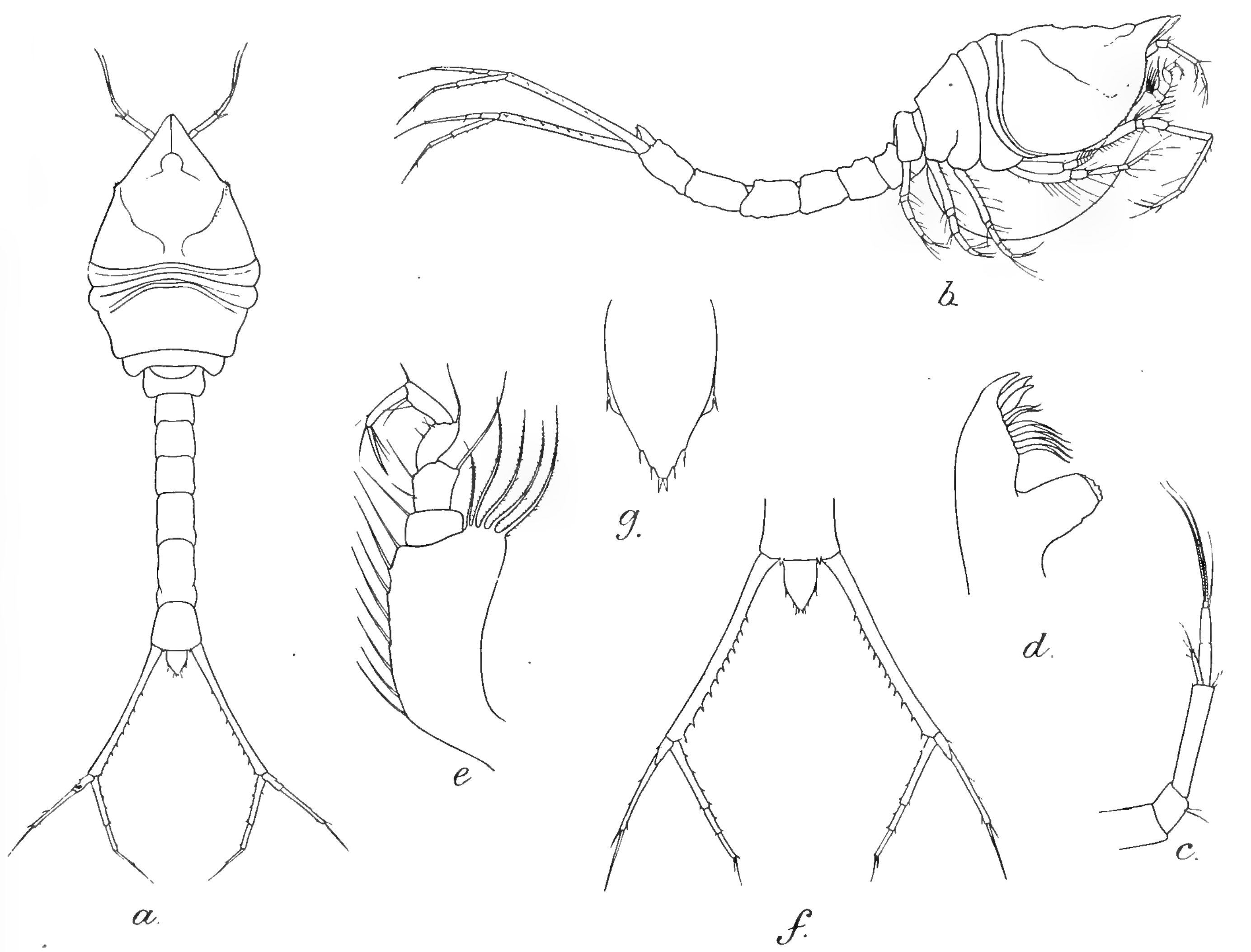


FIG. 3.—*Paradiastylis culicoides*, sp. nov. ♀.

a. Female in dorsal view.
b. Female in lateral view.
c. First antenna.
d. Mandible.
e. Third maxillipede.
f. Telson and uropods.
g. Telson further enlarged.

coarsely reticulate and bears only one oblique lateral ridge in place of the three or four which exist in other known species of the genus. The single ridge, which corresponds to the foremost of those found in allied forms, is very strong anteriorly with its edge microscopically spinulose. Posteriorly each ridge approaches, but does not reach, the median line of the carapace; it is then continued backwards and outwards, becoming very indistinct in this part of its course. Anteriorly the carapace

[1] *Das Tierreich: Cumacea*, p. 7 (1913).

is slightly elevated in the median line and the dorsal margin is rather uneven in lateral view; on either side of this elevation there is an obscure longitudinal ridge. The pseudorostral lobes are not upturned. Close to the apex the inferior margin of each is serrated and the lower margin of the carapace, behind the exceedingly shallow antennal notch, is armed with a series of coarse teeth, some twenty-five in number.

The third and fourth leg-bearing somites appear to be fused dorsally, as in Calman's *P. longipes*.

The abdominal somites are without lateral serrations. The sixth somite bears a pair of small spinules distally, one on either side of the telson.

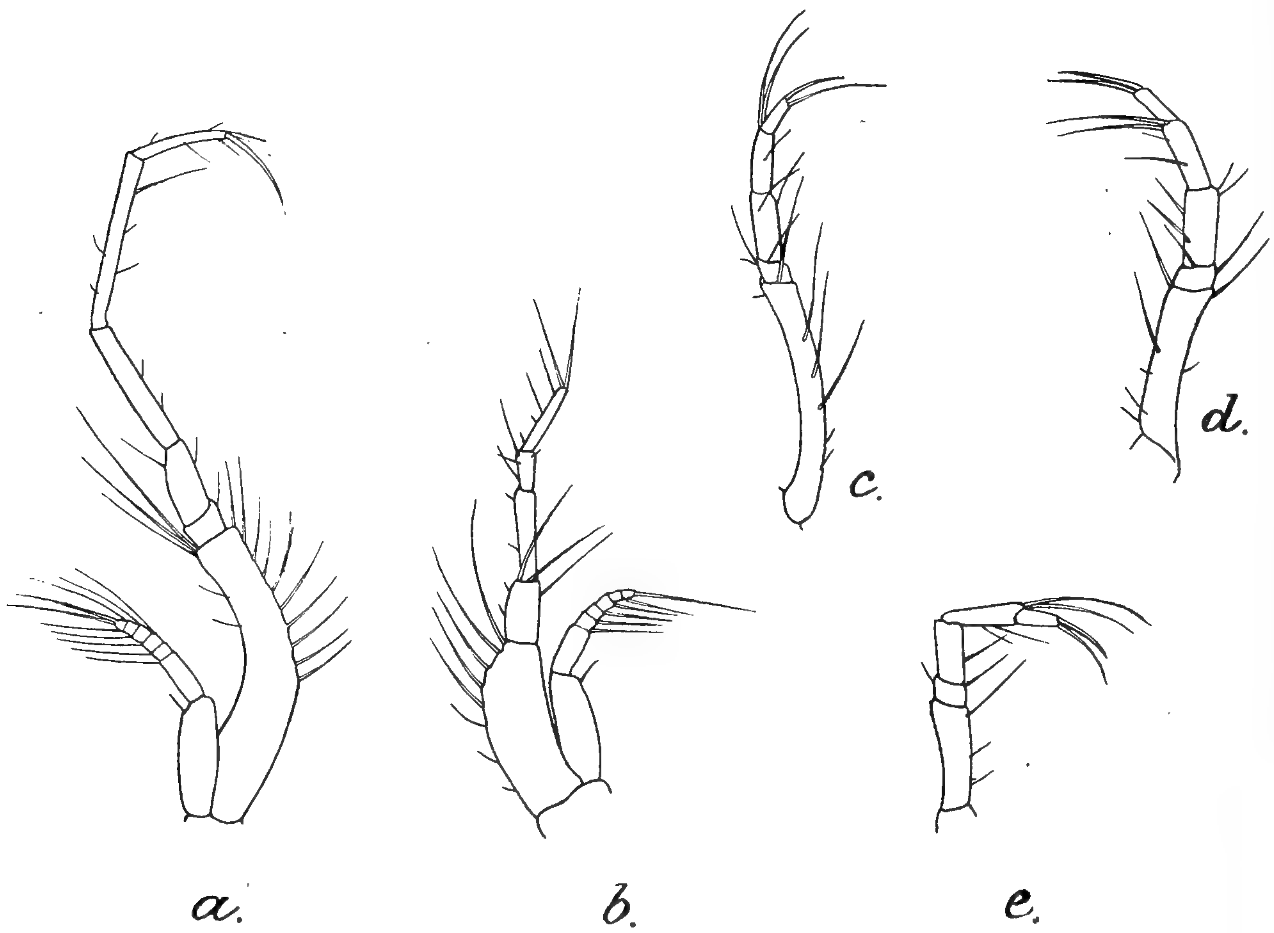


FIG. 4.—*Paradiastylis culicoides*, sp. nov. ♀.

a. First leg.
b. Second leg.
c. Third leg.
d. Fourth leg.
e. Fifth leg.

The telson (text-fig. 3 *g*) is smaller than that of the allied species, being little more than half the length of the last abdominal segment. The apex bears a pair of small spinules flanked on either side by two setae.

The form of the mandible is shown in text-fig. 3 *d*.

The antennules (text-fig. 3 *c*) are apparently much as in *P. longipes*, the third segment of the peduncle being slender and about as long as the first two taken together. The larger flagellum terminates in two annulated filaments.

The third maxillipedes (text-fig. 3 *e*) are without exopods; the basis is exceptionally broad.

The first and second pairs of peraeopods (text-figs. 4*a*, *b*) bear exopods. The former reach beyond the tip of the pseudorostrum by about half their length, the exopod, though longer than in *P. longipes*, being shorter than the basis. In their proportional lengths the segments of the endopod in this limb agree closely with Calman's figure of *P. longipes*. The remaining peraeopods (text-figs. 4*c–e*) are slender.

The uropods (text-fig. 3*f*) are long and slender; the peduncle is very nearly three times the length of the sixth somite and bears from 8 to 12 spines on its inner margin. The exopod (excluding the terminal seta) is as long as the first two seg-

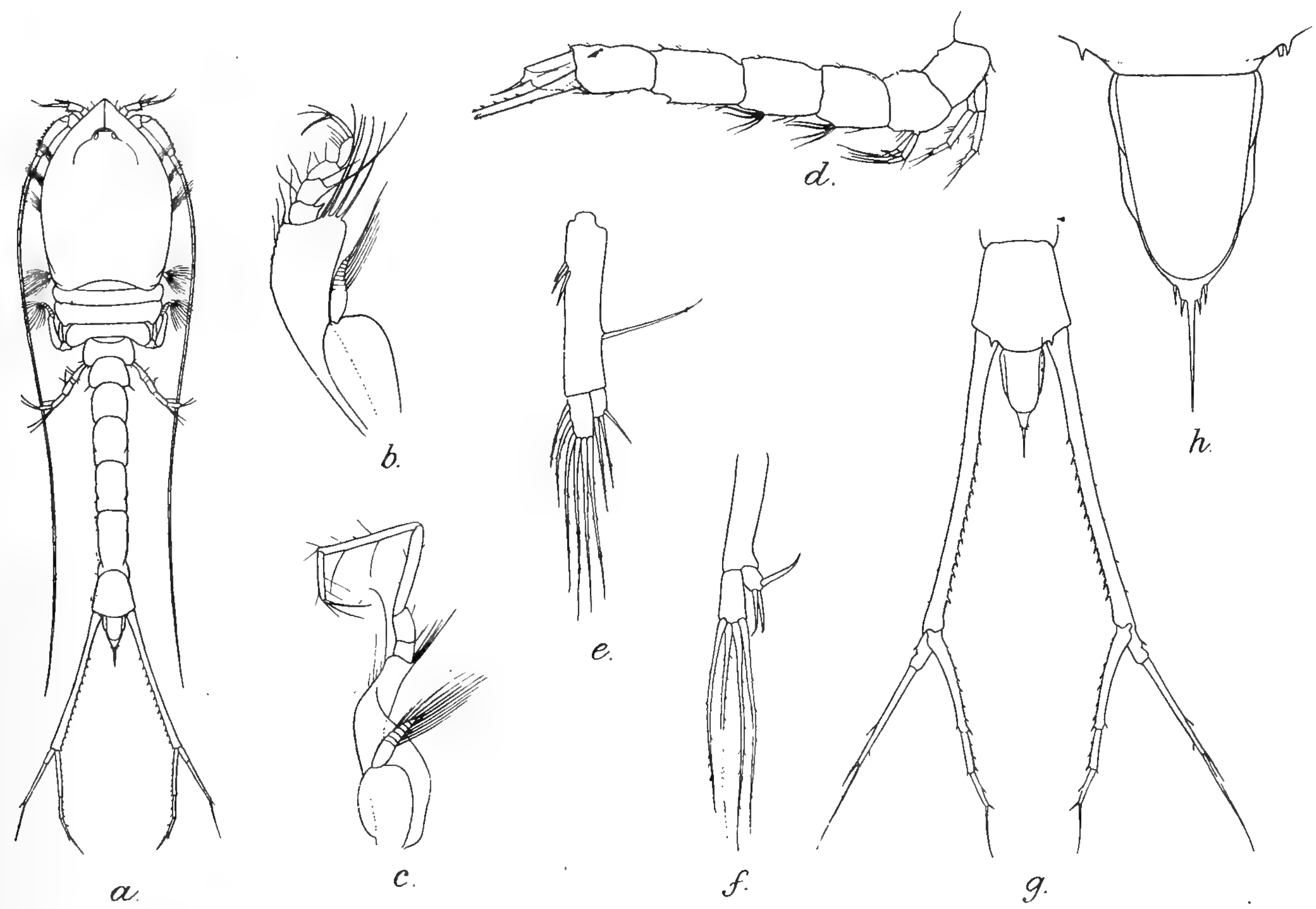


FIG. 5.—*Paradiastylis culicoides*, sp. nov. ♂.

a. Male in dorsal view.
b. Third maxillipede.
c. First leg.
d. Abdominal segments and telson in lateral view.
e. First pleopod.
f. Second pleopod.
g. Telson and uropods.
h. Telson further enlarged.

ments of the endopod and is half the length of the peduncle. Of the three segments composing the endopod the first is longer than the two following combined. The first segment bears four short spines on its inner margin and the second two.

Male.—The male (text-fig. 5*a*) is more slender than the female and shows merely the faintest trace[1] of the oblique ridge on the carapace. The pseudorostrum is also noticeably shorter and there are fewer teeth (only about ten) on the margin of the carapace behind the insertion of the antennae. The ocular lobe appears to be pro-

[1] Not shown in text-fig. 5*a*.

vided with four corneal lenses, one on each side and a pair, partially fused in the middle. The third and fourth leg-bearing somites are quite distinct and there may be a pair of spines on the last abdominal somite on either side of the telson.

The telson (text-fig. 5 *h*) is longer than in the female and is totally different in form. The upper surface is flattened and U-shaped in outline and posteriorly slopes sharply downwards to a long drawn-out apex resembling a large spine. There are two setae on either side at the base of this spine, but there is no trace of the pair of terminal spinules found in the female.

The ultimate peduncular segment of the antennule is enlarged and bears sensory setae. As in *P. longipes* both inner and outer flagella are composed of four segments. The terminal segment of the antennal peduncle is provided with eleven transverse rows of setae.

The third maxillipedes (text-fig. 5 *b*) have a well-formed exopod and the basal segments of the first four legs are greatly expanded and their exopods very strongly developed.

The pleopods on the first and second abdominal segments are illustrated in text-figs. 5 *e*, *f*. On the third and fourth segments (text-fig. 5 *d*) they are replaced by two pairs of long setae, on the fifth by a pair of backwardly directed teeth, each bearing a small setae behind the apex. On the sixth there is a single pair of setae.

The uropods (text-fig. 5 *g*) are more slender than those of the female, but do not differ markedly in structure.

Large females of *P. culicoides* reach a total length of about 4 mm.; males are a trifle smaller, rarely exceeding 3½ mm.

The species differs conspicuously from all others of the same genus in the presence of only a single oblique ridge on the carapace.

Living females in their form and movements bore a curious resemblance to pupae of mosquitoes. Both sexes were of a pale brown colour.

We obtained females in abundance in all parts of the main area of the lake in nets drawn over the surface of the mud at depths of from 6 to 12 ft. Males were found in company with the females, but were much scarcer. A few females were found at the inner end of the outer channel in September in water that was almost or quite fresh. Earlier in the year, when the water in this locality was as salt as that of the sea in the vicinity of the lake, we failed to find any specimens. The species is evidently a permanent inhabitant of the main area of the lake, living in water that varies in specific gravity from 1·000 to 1·015.

The three species of the genus hitherto known are recorded from Japan, the Gulf of Manaar, the Sulu Archipelago and the Gulf of Siam.

FAUNA OF THE CHILKA LAKE

FISH.

PART I.

By B. L. Chaudhuri, *D.Sc.* (*Edin.*), *F.R.S.E.*, *F.L.S.*

(With 11 text-figures.)

CONTENTS.

FISH. (*PART I.*)

By B. L. CHAUDHURI.

This part contains a systematic treatment of the Sub-orders Selachii and Batoidei of the Order Plagiostomi and of two Sub-orders (Malacopterygii and Ostariophysi) of the Order Teleostei. The total number of specimens examined and recorded in this part is 823, which are found to belong to forty-two species. Of these four are new to science. These forty-two species fall into twenty-five genera belonging to nine different families. The geographical and biological results of my study of the fish fauna of the lake will be discussed on the completion of the systematic notice of the entire collection.

Order PLAGIOSTOMI.

Suborder *SELACHII.*

Family CARCHARINIDAE.

Genus **PHYSODON**, Müller and Henle.

Physodon mulleri, Müller and Henle.

1841. *Carcharias* (*Physodon*) *mulleri*, Müller and Henle, *Plagiost.*, p. 30, pl. xix, fig. 1.
1878. *Carcharias mulleri*, Day, *Fish. Ind.*, p. 713.
1889. *Carcharias mulleri*, Day, *Faun. Brit. Ind.*, *Fish.*, I, p. 11.
1913. *Physodon mulleri*, Garman, *Mem. Mus. Comp. Zool.* (Harvard), XXXVI, p. 108.

One young specimen (female), 355 mm. in total length, was collected at Rambha in March 1914.

The teeth are not serrated; their cusps are long with broad and somewhat swollen bases, bent towards the angle of the mouth; on the upper jaw there is a small median tooth and there are two small teeth on the symphysis of the lower jaw. The head is broader than deep; the snout is pointed and is about one-third of the distance from the tip of the snout to the fifth gill-cleft; the nostrils are very close to the mouth, their distance from it being only one-fifth of the distance from the tip of the snout to the mouth; the mouth is greatly arched; the eyes, which are lateral, are small and are provided with a nictitating membrane at least on the anterior side; the gill-clefts are wider than the eyes. The second dorsal fin is very small and extends a little further back than the anal fin; there is a distinct pit anterior to the root of the caudal fin. The denticles are very small and numerous.

To judge from the part of the lake in which it was obtained, it is probable that the species is a permanent inhabitant in the main area.

Distribution :—Bengal and China.

Genus **CARCHARINUS**, Blainville.

Carcharinus gangeticus (Müller and Henle).

1841. *Carcharias (Prinodon) gangeticus*, Müller and Henle, *Plagiost.*, p. 39, pl. xiii.
1878. *Carcharias gangeticus*, Day, *Fish. Ind.*, p. 715, pl. clxxxvii, fig 1.
1889. *Carcharias gangeticus*, Day, *Faun. Brit. Ind., Fish.*, I, p. 13.
1913. *Carcharinus gangeticus*, Garman, *Mem. Mus. Comp. Zool.* (Harvard), XXXI, p. 139.

A specimen was obtained at Satpara in March 1914, the total length of which is 747 mm. The jaw of a young fish was also secured at Rambha in February of the same year. The length and the breadth of this jaw are 68 mm. and 43 mm. respectively. There are 27 rows of teeth in the upper jaw with five teeth in each row and 25 rows in the lower jaw with 6 teeth in each row. There is only one tooth in the middle of each jaw and it is very small. The rest of the teeth are fairly large, generally with long cusps and broad bases, and their margins are serrated; in the end rows, however, the cusps are very short and bent inwards with the bases somewhat swollen.

The species is found in the main area and is probably a permanent inhabitant of the lake.

Distribution:—The species is met with in the seas and estuaries of India, in Japan, the Fiji Islands and at Baghdad. Individuals are known to ascend rivers above tidal influence.

Carcharinus melanopterus (Quoy and Gaimard).

1824. *Carcharias melanopterus*, Quoy and Gaimard, *Voy. Uran. Poiss.*, p. 194, pl. xliii, figs. 1 and 2.
1878. *Carcharias melanopterus*, Day, *Fish. Ind.*, p. 715, pl. clxxxv, fig. 3.
1889. *Carcharias melanopterus*, Day, *Faun. Brit. Ind., Fish.*, I, p. 14.
1913. *Carcharinus melanopterus*, Garman, *Mem. Mus. Comp. Zool.* (Harvard), XXXVI, p. 134.

There is no specimen of this species in the collection. Dr. Jenkins, however, reported (*Rec. Ind. Mus.*, V, p. 135) that he obtained the species at Satpara in December, 1908. Probably it is an occasional visitor to the outer channel when the water becomes brackish.

Distribution:—This species is found in the seas of India and of the Malay Archipelago.

Suborder *BATOIDEI.*

Family PRISTIDAE.

Genus **PRISTIS**, Klein.

Pristis pectinatus, Latham.

1794. *Pristis pectinatus*, Latham, *Trans. Linn. Soc.*, II, p. 278, pl. xxvi, fig. 2.
1822. *Squalus pectinatus*, Hamilton Buchanan, *Fish. Gang.*, pp. 5, 361.
1841. *Pristis pectinatus*, Müller and Henle, *Plagiost.*, p. 109.
1878. *Pristis pectinatus*, Day, *Fish. Ind.*, p. 811.
1889. *Pristis pectinatus*, Day, *Faun. Brit. Ind., Fish.*, I, p. 39.
1909. *Pristis pectinatus*, Annandale, *Mem. Ind. Mus.*, II, p. 7.
1913. *Pristis pectinatus*, Garman, *Mem. Mus. Comp. Zool.* (Havard), XXXVI, p. 262.

In the collection there is only one skull with the rostrum, collected in December, 1914 at Nalbano Island. This is the only record we possess of a sawfish in the lake.

The rostrum from the eye to the tip measures 26·5 mm. There are 26 teeth on the right and 23 on the left. The teeth on the left side nearer the head are most irregular. The width of the rostrum in the middle portion is nearly uniform, being 30 mm. At the tip it is only 17 mm. and at the base 50 mm.

This species appears to be only an occasional visitor to the lake.

Distribution :—Tropical and temperate seas, the Red Sea, the Indian Ocean and beyond.

Family TRYGONIDAE.

Genus **TRYGON**, Cuvier.

Trygon uarnak (Forskål).

1775. *Raia uarnak*, Forskål, *Descript. Anim.*, pp. viii, ix.
1878. *Trygon uarnak*, Day, *Fish. Ind.*, p. 737 (in part).
1889. *Trygon uarnak*, Day, *Faun. Brit. Ind.*, *Fish.*, I, p. 53 (in part).
1909. *Trygon uarnak*, Annandale, *Mem. Ind. Mus.*, II, p. 22, pl. i, figs. 1 and 2; pl. ii. figs. 1 and 1*a*; pl. iii, fig. 2*c*.
1910. *Trygon uarnak*, Gunther, *Sudsee Fische*, III, p. 492.
1913. *Dasybatus uarnak*, Garman, *Mem. Mus. Comp. Zool.* (Harvard), XXXVI, p. 376.

There is only one young specimen (female) in the collection; it was purchased from a fisherman at Satpara. The dorsal surface is covered with round and black spots on a greyish white ground. The measurements of the specimen are given below:—

Breadth across disk	290 mm.
Tip of snout to root of tail	264 ,,
Mouth to vent	177 ,,
Length of tail	720 ,,
Breadth of the mouth	25 ,,
Interorbital space	49 ,,
Length of snout	71 ,,

The species is a permanent inhabitant of the lake, in the shallower parts of which it is common.

Distribution :—Indian Ocean, Red Sea, Gulf of Siam, East Indies.

Trygon pareh, Bleeker.

1851. *Trygon pareh*, Bleeker, *Verhand. Batav. Genoots.*, p. 71, t. xxiv.
1860. *Trygon ellioti*, Blyth, *Journ. Asiat. Soc. Bengal*, xxix, p. 41.
1865. *Trygon pareh*, Duméril, *Hist. Nat. Poiss.*, I, p. 590.
1909. *Trygon alcockii*, Annandale, *Mem. Ind. Mus.*, II, p. 27, text-fig. 3.

This is a medium-sized *Trygon*, the disk of which is slightly broader than long, with the pectoral angles rounded. The snout is pointed and forms nearly a right angle at its extremity. The interorbital distance is contained about one and half times in the length of the snout and four and a half times in the length of the disk, which is moderately flat. Of the four specimens collected a young one has a smooth central dorsal tubercle and another behind it, surrounding which there is a group of

small tubercles indefinitely scattered. In this species the denticles do not form as definite a pattern as in *Trygon gerrardi.* The tail is provided with a single serrated spine, and its dorsal and lateral surfaces are uniformly covered with denticles. The cross-section of the tail anterior to the spine is distinctly flattened, which character marks it off from allied species, in all of which the cross-section in that position is circular. In a young male specimen the tail is more than three and a half times the length of the disk, but in an adult female its length (perhaps mutilated) is only one and a half times that of the disk.

Colour:—The dorsal surface of the disk is dark olive-brown and the dorsal and lateral surfaces of the tail are also brown without markings; the ventral surface (including the base of the tail) is white suffused with pink. The measurements of the four specimens in the collection are given below:—

	Adult ♂, Nalbano, Nov. 1914.	Adult ♀, Balugaon, 2-i-15.	Adult ♀, Balugaon, 4-i-15.	Young ♂, Balugaon, 5-i-15.
	mm.	mm.	mm.	mm.
Breadth of disk	530	582	546	198
Length of disk	512	582	538	190
Distance between the eyes ..	68	71	66	38
Snout	106	127	117	43
From the broadest part of the disk to the end of the snout.	215	242	221	68
Breadth of mouth ..	43	51	49	17
Distance between mouth and vent	317	381	320	144
Tail	912	Mutilated	762	594

The adult female from Balugaon collected on the 2nd of February, 1915 is slightly peculiar in the shape of the disk, the angle at the snout being somewhat obtuse; its caudal spine is wanting but perhaps it was lost during life; the tail, which is very short, must have been mutilated, and is, moreover, less flat than in the rest of the specimens.

This species is a permanent inhabitant of the main area, probably breeding in the lake.

Distribution:—R. Hughli, Bay of Bengal, Malay Archipelago.

Trygon imbricata (Schneider).

1801. *Raia imbricata*, Schneider, Bloch's *Ichthyol.*, p. 366.
1841. *Trygon imbricata*, Müller and Henle, *Plagiost.*, p. 164.
1841. *Trygon walga*, Müller and Henle, *ibid.*, p. 159, pl. li, fig 1.
1878. *Trygon imbricata*, Day, *Fish. Ind.*, p. 739.

1889. *Trygon imbricata*, Day, *Faun. Brit. Ind.*, *Fish.*, I, p. 52.
1909. *Trygon imbricata*, Annandale, *Mem. Ind. Mus.*, II, p. 32, text-fig. 6, pl. iii, fig. 5.
1913. *Dasybatus imbricatus*, Garman, *Mem. Mus. Comp. Zool.* (Harvard), XXXVI, p. 379.

This small *Trygon* is very common all over the lake-system at all times of the year and breeds in the lake. There are three adult specimens in the collection; one was obtained off Samal Island (22-ix-13), one at Rambha (February, 1914) and the other at Balugaon (5-i-15). Besides these, there are four embryos two of which are small males and the other two still smaller females. The female embryos are slightly longer than broad, whereas in the males the disk is almost as broad as long. The length of the tail in the male embryos is nearly double the length of the disk, whereas in the female embryos the tail is only slightly longer than that of the disk. As the tails in these cases cannot have been mutilated, these proportions are of interest. The localities with the measurements of the embryos are given below. The two younger embryos have the numerous trophonematous filaments still present on all the gill-slits.

Locality and date of collection.	Length of disk in mm.	Breadth of disk in mm.	Length of tail in mm.	Length of umbilical cord in mm.
Barkul, Sept. 1914 ♂	60	60	105	U. C. broken, no filaments.
Patsahanipur, 8-iii-14 ♂	46	45	60	U. C. 15 mm. with a bulbular yolk sac at the end, no filaments.
Outer Channel, Satpara, 21-iii-14 ♀	33	30	40	U. C. 17 mm. with y. s. at the end, numerous filaments entering gill slits.
Ditto ♀	27	24	30	U. C. 13 mm. with y. s. at the end, numerous filaments entering gill slits.

The food of this species consists chiefly of Amphipods and other small Crustacea and of burrowing Molluscs such as *Solen*.

The alimentary canal is remarkably free from parasites.

Distribution:—East Indies.

Genus **HYPOLOPHUS**, Müller and Henle.

Hypolophus sephen (Forskål).

1775. *Raia sephen*, Forskål, *Descript. Anim.*, p. 17, no. 16.
1822. *Raia sancur*, Hamilton-Buchanan, *Fish. Gang.*, pp. 2, 361.
1841. *Hypolophus sephen*, Müller and Henle, *Plagiost.*, p. 170.
1878. *Trygon sephen*, Day, *Fish. Ind.*, p. 740, pl. cxcv, fig. 2.
1889. *Trygon sephen*, Day, *Faun. Brit. Ind.*, *Fish.*, I, p. 50, fig. 21.
1909. *Hypolophus sephen*, Annandale, *Mem. Ind. Mus.*, II, p. 35, pl. v, fig. 1.
1913. *Dasybatus sephen*, Garman, *Mem. Mus. Comp. Zool.* (Harvard), XXXVI, p. 384.

This large species of fringe-tailed sting-ray is found everywhere in the lake-system and always in very large numbers in the main area. It breeds in the lake. Together with *Trygon fluviatilis* (H.B.), it has long been known to produce its young in fresh water in India (*Journ. Asiat. Soc. Bengal* (n.s.), VI, p. 497).

The measurements of two embryos are given below; one, a male, is very young, while the other—a female—is almost fully formed. The disk of the younger embryo is much longer than broad, in the advanced embryo it is as broad as long, while in the normal adult it is rather broader than long.

	Embryo ♀. Barkul, September 1914.	Embryo ♂. Patshanipur, March 1914.
	mm.	mm.
Length of disk	120	22
Breadth of disk	120	17
Interorbital distance	30	6
Snout	30	6
Mouth to vent	100	17
Tail	320	33
Umbilical cord	35	12
Yolk sac..	5 × 2	10 × 3
Filament	None.	Numerous entering gill-slits.

The food of this species consists chiefly of fish and prawns. In one instance the stomach was found full of weed, which had probably been swallowed for the sake of young molluscs (*Modiola undulata*) attached to it.

The following Cestodes[1] were found in the alimentary canal of specimens taken in the lake:—

Phyllobothrium pammicrum, Shipley and Hornell.

Parataenia medusia, Linton.

Calliobothrium eschrichtii, Van Ben.

The Trematode *Anaporrhutum largum*, Lühe, was found in the body cavity in two cases (Southwell, *op. cit.*, p. 335).

The Ray appears to have no fixed breeding-season.

In fine weather individuals often lie just below the surface of the water gently undulating their pectoral fins.

Distribution:—Indian Ocean, Red Sea, East Indies.

[1] *See* Southwell, *Rec. Ind. Mus.*, XI, p. 331.

Family MYLIOBATIDAE.

Genus AETOBATIS, Blainville.

Aetobatis flagellum (Schneider).

1801. *Raia flagellum*, Schneider, Bloch's *Ichthyol.*, p. 361, pl. lxxiii.
1841. *Aetobatis flagellum*, Müller and Henle, *Plagiost.*. p. 180.
1870. *Aetobatis narinari*, Gunther, *Cat. Fish. Brit. Mus.*, VIII, p. 492.
1878. *Aetobatis narinari*, Day, *Fish. Ind.*, 743, pl. cxciv, fig 4.
1889. *Aetobatis narinari*, Day, *Faun. Brit. Ind.*, *Fish.*, I, 59.
1909. *Aetobatis flagellum*, Annandale, *Mem. Ind. Mus.*, II, p. 54, text-fig. 10, pl. iv, fig. 5.
1913. *Aetobatus flagellum*, Garman, *Mem. Mus. Comp. Zool.* (Harvard), XXXVI, p. 440.
1914. *Aetobatus flagellum*, Gudger, *Pub. Carn. Inst.* (Washington), CLXXXIII, p. 312.

There is one female specimen in the collection secured by purchase at Barkul. A large number of dead *Aetobatis flagellum* were seen lying on the Island of Nalbano by Dr. Annandale in the month of March, 1914. A severed head of the species was brought by Dr. Jenkins from the mouth of the Chilka Lake in December, 1909. In the specimen from Barkul the snout is very long and tapers to a sharp point and is much longer than broad. The eyes are lateral; their dorso-ventral axis is vertical and forms a right angle with the upper surface of the head. The distance from the mouth to vent is contained three times in the width of the disk. The teeth of the lower jaw are strongly curved and the pointed end of the band is seen projecting forward from the mouth. The skin is smooth and of a dark colour and there are no spots.

The measurements of the Barkul specimen are given below:—

Breadth of disk	494 mm.
Mouth to vent	165 ,,
Length of snout	76 ,,
Rostral fin	63 × 2 ,,
Diameter of eye	12·6 ,,
Interorbital space	63 ,,
Length of spiracle	25 ,,
Ventral fin	76 × 28 ,,
Tail	851 ,,

The conclusions Dr. Annandale arrived at about this species in 1909 (*Mem. Ind. Mus.*, II, pp. 54-58) have been now widely accepted.

Distribution:—Tropical and semitropical waters of the world.

Aetobatis guttata (Bloch and Schneider).

1801. *Raia guttata*, Bloch and Schneider, *Syst. Ichthy.*, pp. 361-364.
1803. *Raja* No. viii [*Eel tenkee*], Russell, *Vizag. Fish.*, I, p. 5, pl. viii.
1804. *Raia guttata*, Shaw, *Zool.*, V, p. 285.
1839. *Aetobatis indica*, Swainson, *Fish.*, II, p. 3.
1849. *Stoadson narinari*, Cantor, *Cat. Mal. Fish.*, p. 1416.
1865. *Aetobatis narinari*, Day, *Fish. Malab.*, p. 280.
1870. *Aetobatis narinari*, Gunther, *Cat. Fish. Brit. Mus.*, VIII, p. 493.

1878. *Aetobatis narinari*, Day, *Fish. Ind.*, p. 743.
1889. *Aetobatis narinari*, Day, *Faun. Brit. Ind., Fish.*, I, p. 59.
1909. *Aetobatis guttata*, Annandale, *Mem. Ind. Mus.*, II, pp. 55-56, text-fig. 10.
1913. *Aetobatis ocellatus*, Garman, *Mem. Mus. Comp. Zool.* (Harvard), XXXVI, p. 442.
1914. *Aetobatis guttata*, Gudger, *Pub. Carn. Inst.* (Washington), CLXXXIII, p. 313.

Gudger, in his paper on the *History of the Spotted Eagle Ray* on page 313, has shown that the specific name *guttata* was first employed by Bloch and Schneider in 1801. It would therefore have priority over "*ocellata*" of Russell (1803). In any case, however, the latter is inadmissible as it is merely used by Russell in a descriptive sense; the same term (*ocellata*) had been used by him exactly similarly for his *Raja* No. I and *Raja* No. II, as well as for his No. viii, the present species also referred to by him by the local name *Eel tenkee*. He refrained from giving specific names to any of the species of rays he described or figured [see Russell, *Fish. Vizag.*, I, p. v. (Preface)]. Thus the specific name newly proposed by Garman lapses owing to want of priority.

There are three young male specimens in the collection. The snout in all these specimens is comparatively short, conical, bluntly pointed and distinctly retroverted and agrees with Dr. Annandale's figure of 1909 (*op. cit.*, fig. 10 B, p. 55). The dorso-ventral axis of the eye is inclined downwards and inwards and the pupil is visible from below. The distance between the mouth and the vent is contained $2\frac{1}{2}$ times or a little more in the breadth of the disk, and the length of the tail is more than twice the breadth of the disk. The teeth are in a single series, those of the lower jaw meeting at an obtuse angle and slightly projecting out of the mouth. The skin is smooth with slight roughness; there are no denticles. The dorsal surface is of a uniform dark slate-gray colour without any trace of spots.

The measurements of the three specimens are given below.

	Barkul, ♂ (2-i-15).	Barkul, ♂ (3-i-15).	Balugaon, ♂ (4-i-15).
	mm.	mm.	mm.
Breadth of disk	398	317	496
Mouth to vent	165	114	190
Length of snout	43	35	51
Rostral fin	43 × 40	33 × 35	46 × 46
Diameter of eye	9	8	10
Interorbital space	56	45	56
Length of spiracle	17	16	17
Ventral fin	67 × 28	51 × 24	72 × 28
Tail	1012	797	1063

This species appears to breed freely in the main area of the lake as young specimens are numerous.

Distribution :—Tropical parts of the Indian Ocean.

Genus **AETOMYLAEUS**, Garman.

Aetomylaeus nichofii (Schneider).

1801. *Raia nichofii*, Schneider, Bloch's *Ichthyol.*, p. 364.
1878. *Myliobatis nieuhofii*, Day, *Fish. Ind.*, p. 742.
1889. *Myliobatis nieuhofii*, Day, *Faun. Brit. Ind.*, *Fish.*, I, p. 58.
1909. *Myliobatis nieuhofii*, Annandale, *Mem. Ind. Mus.*, II, p. 51.
1913. *Aetomylaeus nichofii*, Garman, *Mem. Mus. Comp. Zool.* (Harvard), XXXVI, p. 436.

No specimen of this species appears to have been collected but many were observed in the course of the survey. Dr. Annandale tells me that the species is very common in February in the shallows near the outer shore of the south end of the main area of the lake, where it moves about in shoals, occasionally leaping out of the water. The back is brown and is banded with five or six narrow bands of lighter colour which are conspicuous in life and can be seen when the fish is several inches below the surface of the water.

The species is a permanent inhabitant in the main area of the lake.

Distribution :—Seas of India, East Indies and Japan.

Order TELEOSTEI.

Suborder *MALACOPTERYGII.*

Family ELOPSIDAE.

Genus **ELOPS**, Linnaeus.

Elops indicus, Swainson.

(Text-figures 1, 2.)

1803. *Elops saurus* (*nec* Linné), Russel, *Vizag. Fish.*, II, p. 63, pl. clxxix.
1839. *Elops* (*saurus*) *indicus*, Swainson, *Nat. Hist Fish. Amph. Rep.*, II, p. 292.
1846. *Elops saurus*, Cuvier and Valenciennes, *Hist. Nat. Poiss.*, XIX, p. 358.
1868. *Elops saurus*, Günther, *Cat. Fish. Brit. Mus.*, VII, p. 470.
1878. *Elops saurus*, Day, *Fish. Ind.*, p. 649, pl. clxvi, fig. 1.
1889. *Elops saurus*, Day, *Faun. Brit. Ind.*, *Fish.*, I, p. 401, fig. 125.

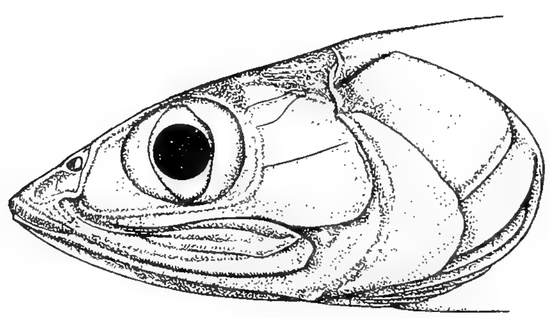
There are altogether nine specimens in the collection; one is from the main area of the lake off Balugaon (6-iii-1914), while the other eight were bought from a fisherman at Rambha on January 1st, 1915.

All these specimens have the lower jaw within the upper jaw and the teeth on the tip of the former entirely exposed (text-figs. 1 and 2): thus the entire collection falls into the '*saurus* group', and not into the '*machnata* group' of the genus.

In his revision of the fishes of the genus *Elops* (*Ann. Mag. Nat. Hist.*, (8), III, p. 37) Tate Regan has divided all the species into two main groups:—one, which may be designated the '*saurus* group,' consists of five species. All have "included" lower jaws and the whole of the praemaxillary band of teeth exposed when the mouth is closed. The other group, which may be termed the "*machnata* group," consists of two species in both of which the lower jaw is projecting and covers the anterior part of the praemaxillary band of teeth when the mouth is closed.

Tate Regan when reviewing the genus had only one specimen from India before him. It was said to have come from Madras. This specimen he referred to *Elops machnata* (Forskål). Some have been led to suppose, therefore, that all the Indian *Elops* belong to this species, which in reality is a species of the Red Sea (see Jordon and Richardson on the *Fishes of Formosa* in *Mem. Carnagie Mus.*, IV, p. 165).

There is a very valuable specimen in spirit (Registered No. 2641) in the collection of the Indian Museum, purchased from Day; it was the original of figure no. 1 of plate



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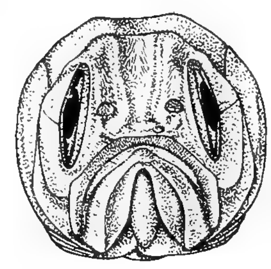


2.

FIG. 1.—*Elops indicus*, Swainson.
Side view of the head, with the mouth closed and the lower jaw included.

FIG. 2.—*Elops indicus*, Swainson.
Anterior part of the head seen from the front, slightly below the horizontal line, with the mouth closed; lower jaw is seen included and the anterior part of the intermaxillary teeth exposed.

clxvi in his *Fishes of India*. This specimen was caught by Mr. H. S. Thomas in a brackish-water enclosure at South Canara, and Mr. Thomas alluded to it in his *Rod in India* (Second Edition, p. 214). In this fish as well as in another specimen of *Elops*, also preserved in spirit, that was bought in the Calcutta market by the Curator of the Museum of the Asiatic Society of Bengal in the early sixties, the lower jaw is included inside the upper, so that the whole of the praemaxillary band of teeth is exposed in both the specimens when the mouth is closed. Neither of these specimens, therefore, can belong to *E. machnata* (Forskål), which I have reason to suspect is not an Indian species at all. Professor Weber and Dr. Beaufort in their *Fishes of the Indo-Australian Archipelago* (Vol. II, p. 4) in describing this species (*i.e.*, *E. machnata*) remarked "not seen by us." Their note a few lines below to the effect that Bean and Weed confirmed the occurrence of *E. machnata* in the Indian Archipelago is not corroborated in the original paper by the latter authors. In this paper, which is on the Fishes of Java (*Proc. U. S. Nat. Mus.*, LXII, p. 589), Bean and Weed stated that they had examined

altogether thirty-five specimens belonging to the genus *Elops*, (*viz.*, seven from Java, three from Ashantee, five from the west coast of America, three from Australia, six from the east coast of America, five from the Philippine Islands, five from Hawaii and one from Hong Kong, China). This series indicated to them that it would not bear out the conclusions reached by Tate Regan. In fact, they thought that their Java specimens represented the species described by Bleeker under the name *Elops saurus* (*nec* Linné) and not *E. machnata* (Forskål).

The Chilka series of the genus *Elops* closely agrees with the Indian species represented by Thomas' specimen from South Canara, as well as with Russel's description and figure (*Vizag. Fish.*, II, p. 63, pl. clxxix). The following extract from Russel's description "the jaws are nearly of equal length, long extractile, the under carinate........the teeth are marginal, small, not close except in the forepart of the lower jaw" clearly shows that in species examined by him the lower jaw was included and the teeth on the praemaxillary exposed. Russel's description of his species is very minute and his figure is excellent. Moreover his vernacular name leaves no doubt about its identity. All these facts make it very clear that Russel's species cannot be *E. machnata* (Forskål). Russel called it *E. saurus*, with the description of which his species agreed very closely. Swainson, however, was first to realize the necessity of the addition of a new name to distinguish the Indian species from the North American one, and therefore named the former *indicus* in his classification of fishes (*Nat. Hist. Fish. Amph. Rep.*, II, p. 292). There was no necessity for Swainson to supply any description, as Russel's description, which he adopted, was very minute and exhaustive. Günther also corroborated Russel's description by saying "the lower jaw scarcely projecting beyond the upper" (*Cat. Fish. Brit. Mus.*, VII, p. 470). Day has made this important distinction still more clear with reference to the Indian species by saying that "*the under jaw slightly shorter than the upper*" (*Fish. Ind.*, II, p. 650). Thus one is compelled to believe that Russel's species of *Elops* as well as Thomas' specimen, drawn and described by Day, belong to one and the same species as the Chilka form, for all of which Swainson's name *indicus* should stand on the grounds of priority. *Elops machnata* (Forskål), which is said to be a species of the Red Sea by Jordan and Richardson (*op. cit.*), is very different from the Chilka specimens because in *E. machmata* the lower jaw is not only decidedly longer than the upper jaw but it completely covers the teeth on the praemaxillary bone when the mouth is shut. Of course in dried and stuffed specimens the lower jaw may get artificially fixed to look longer, hence the necessity of an examination of spirit specimens in which the natural position of the jaws is not at all interfered with. No specific locality for Tate Regan's Madras specimen is given; it is therefore difficult to say whether it is a Red Sea specimen forwarded through Madras, or whether it is an imperfectly mounted stuffed specimen in which the lower jaw was artificially fixed further forward than was natural in the species.

The Chilka form, as has been already shown, falls under the "*saurus* group" in which Tate Regan has proposed as many as five species; with the validity of such a large number of species, founded on slight differences under the *saurus* group of the

genus we are not at present concerned, as the Chilka species differs from all of the new species in proportions, etc. It should, however, be mentioned that Bean and Weed (*op.cit.*), after examining a large number of specimens belonging to the genus from different localities, felt that all these new species proposed by Regan were only closely allied forms. The Chilka species differs considerably from *E. hawaiensis* and the other new species proposed and described by Tate Regan. It comes nearest on the whole to *E. saurus*, Linn., re-described by Regan in his revision, except in the number of vertebrae. Bean and Weed (*op.cit.*) ascertained the number of vertebrae in different groups according to localities. These figures are interesting and are quoted below :—

East Coast of America (Skeleton)		$75\frac{1}{2}$
West Coast of America (Radiograph)		$79\frac{1}{2}$
Ashanti, West Africa	Do.	$69\frac{1}{2}$
Hawaii	Do.	$68\frac{1}{2}$
Hong Kong, China	Do.	$65\frac{1}{2}$
Philippine Islands	Do.	$65\frac{1}{2}$
Java	Do.	$65\frac{1}{2}$

In the Chilka forms the number of vertebrae is sixty-six, following Tate Regan's method of counting the upwardly directed hypural portion as representing three vertebrae.

For comparison the proportions of measurements of the Chilka specimens are given below. The total length of those collected is from 280 mm. to 340 mm., but the fish is said to grow considerably bigger.

The depth of the body is contained nearly six and a half times in the total length (without caudal), the length of the head four and a half times. The length of the snout is equal to the diameter of the eye as well as to the inter-orbital width, which is contained four and a half times in the length of the head. The maxillary bone extends considerably beyond the eye ; the lower jaw is included inside the upper when the mouth is closed. The length of the gular plate is two-thirds of the length of the lower jaw, which is again four-seventh times the length of the head. The number of branchiostegal rays is twenty-eight. The number of the scales in the longitudinal series in the lateral line is one hundred and two, in the transverse series above the lateral line there are fourteen rows of scales, fifteen rows below the lateral line, and there are twelve rows of scales between the lateral line and the ventral fins. The dorsal fin contains twenty-four rays of which eighteen are branched. The anal fin has thirteen branched rays out of a total of sixteen. The length of the pectoral fin is slightly greater than half the length of the head. The depth of the caudal peduncle is a little less than three-eighths of the length of the head. The number of vertebrae is 66.

The fish is found in large numbers during the winter months in the main area of the lake, but probably does not breed in it as there is not a single young specimen in the collection.

Distribution :—The Bay of Bengal and the Arabian Sea, entering the estuaries.

Genus **MEGALOPS**, Lacépède.

Megalops cyprinoides (Broussonet).

1782. *Clupea cyprinoides*, Broussonet, *Ichthyol.*, Dec. I, tab. ix.
1803. *Clupea cyprinoides*, Russel, *Vizag. Fish.*, II, p. 81, pl. cciii.
1803. *Megalops filamentosus*, Lacépède, *Hist. Nat. Poiss.*, V, p. 289.
1822. *Cyprinodon cundinga*, Hamilton Buchanan, *Fish. Gang.*, p. 154.
1839. *Megalops cyprinoides*, Swainson, *Nat. Hist. Fish. Amph. Rep.*, II, p. 293.
1846. *Megalops indicus*, Cuvier and Valenciennes, *Hist. Nat. Poiss.*, XIX, p. 388, pl. 576.
1878. *Megalops cyprinoides*, Day, *Fish. Ind.*, p. 650, pl. clix, fig. 3.
1889. *Megalops cyprinoides*, Day, *Faun. Brit. Ind.*, *Fish.*, I, p. 402, fig. 126.

There are two specimens in the collection; the larger one, 250 mm. in length (without caudal), was collected at Rambha at the end of the year 1914 and the smaller one (190 mm. in length) was caught near Barkul in September, 1914.

The mouth is superior, and the lower jaw, which is very prominent, goes to form a part of the upper profile of the snout. The Chilka specimens do not show any noticeable peculiarity.

This fish occurs in the main area of the lake after the rains and continues there during the winter months.

Distribution:—The Indian and the Pacific Oceans and their estuaries. The fish is often found in brackish waters and is occasionally met with in freshwater ponds.

Family CHANIDAE.

Genus **CHANOS**, Lacépède.

Chanos chanos (Forskål).

1775. *Mugil chanos*, Forskål, *Descript. Anim.*, p. 74.
1801. *Mugil salmoneus*, Bloch and Schneider, *Syst. Ichthy.*, p. 121.
1803. *Chanos arabicus*, Lacépède, *Hist. Nat. Poiss.*, V, p. 396.
1871. *Chanos chanos*, Klunz, *Fisch. R.M.*, p. 605.
1878. *Chanos salmoneus*, Day, *Fish. Ind.*, p. 651, pl. clxvi, fig. 2.
1889. *Chanos salmoneus*, Day, *Faun. Brit. Ind.*, *Fish.*, I, p. 403, fig. 127.

There is no specimen in the collection. The fish is, however, reported to be caught occasionally in the main area during the rains. Its ripe roe, dried and smoked, is sold by the fishermen of Barkul and other villages bordering on the lake.

Distribution:—The Indian and the Pacific Oceans and their estuaries; the Red Sea, the east coast of Africa and Madagascar.

Family CLUPEIDAE.

Subfamily *DOROSOMATINAE*.

Genus **DOROSOMA**, Rafinesque.

Dorosoma nasus (Bloch).

1795. *Clupea nasus*, Bloch, *Aus. Fische*, IX, p. 116.
1803. *Clupea thrissa* (L.), Russel, *Vizag. Fish.*, II, p. 76, pl. cxcvi.
1803. *Clupea* sp. (*Pedda Kome*), *ibid.*, p. 77, pl. cxcvii.
1830. *Chatoessus altus*, Gray and Hardwicke, *Ill. Ind. Zool.*, pl. xci, fig. 2.

1848. *Chatoessus nasus*, Cuv. and Valenciennes, ***Hist. Nat. Poiss.***, XXI, p. 164.
1878. *Chatoessus nasus*, Day, *Fish. Ind.*, p. 634, pl. clx, fig. 4.
1889. *Chatoessus nasus*, Day, *Faun. Brit. Ind., Fish.*, I, p. 387, fig. 120.

Russel made out two species in this mud-eating fish in which the last ray of the dorsal fin is greatly elongated. In so doing he simply followed the Telegu fishermen who distinguished two different kinds of fish among them by two different names, *viz.* *Kome* and *Pedda Kome* (*Pedda* = big). Russel has two figures, plate 196 representing *Kome* and plate 197 representing *Pedda Kome*, but neither of these figures show the conspicuous bluish black blotch behind the opercles characteristic of the species (at least in the adult stage). There are sixteen specimens in the Chilka collection, of these seven possess the blotch about three scales deep behind the opercle, measuring in larger specimens 15 mm. × 6 mm. In full-grown specimens the elongated ray almost reaches the root of the caudal fin, falling short by the breadth of two scales. Among the smaller specimens none have any blotch behind the opercle, and the elongated ray is proportionately shorter. Probably the want of the coloured blotch and the comparative shortness of the elongated ray in the young led the coast fishermen to use two different names for the same fish. Russel noticed a difference in the distance between the nostrils in his two species, but no such difference is noticed in any of the specimens of this collection. The Chilka fishermen have only one name, *Bolangi* (both for the fish with a blotch and for the fish without it. The lengths of the specimens in the collection, together with the lengths of the respective elongated ray, and the presence or absence of the coloured blotch are stated below.

Locality and date.	Number of specimens.	Total length in mm.	Length of the elongated ray in mm.	Presence or absence of a bluish black blotch.
Barkul, Sept. 14	1	171	66	Present. Three scales behind the opercle, 15 × 6.
Parikud, 28-xi-14	1	169	61	Present.
Patsahanipur, 3-ii-14	2	125	Damaged.	Present.
Off north side of Samal Island, 24-ii-14	1	102	41	Five scales behind opercle, 7 × 3 mm.
Barkul, 4-i-15	2	96	36	Present.
Off Nalbano, 18-ix-14	1	63	18	Absent.
Barkul, 4-i-15	1	53	9	Do.
Satpara, March 14	1	52	8	Do.
Rambha Bay, 22-vii-14 ..	1	45	9	Do.
Do. ..	1	44	5	Do.
Do. ..	2	43	5	Do.
Do. ..	2	42	4	Do.

The last six specimens have a longitudinal silvery band about half way down.

The fish is found all over the lake throughout the year, probably breeding in it.

Distribution :—Seas of India to the Malay Archipelago, Philippines, Formosa, China, South Arabia and Sokotra.

Dorosoma indicus (Russel).

1803. *Harengus minor indicus*, Russel, *Vizag. Fish.*, II, p. 70, pl. clxxxvi, fig. 1.
1822. *Clupanodon chakunda*, Hamilton Buchanan, *Fish. Gang.*, p. 246.
1833. *Clupia mauritiana*, Bennet, *Proc. Zool. Soc.*, p. 32.
1848. *Chatoessus chacunda*, Cuv. et Val., *Hist. Nat. Poissons*, XXI, p. 111.
1866. *Dorosoma chakunda*, Bleeker, *Atl. Ichth.*, VI, p. 143, t. 261, figs. 5 & 6.
1878. *Chatoessus chakunda*, Day, *Fish. Ind.*, p. 632, pl. clx, fig. 3.
1889. *Chatoessus chakunda*, Day, *Faun. Brit. Ind.*, *Fish.*, I, p. 386.

Of the three specimens in the survey collection two are without the black spot behind the opercle said to be characteristic of the species. One of these is a young specimen measuring 47 mm. from Rambha Bay (22-vii-14), which is without any spot. The specimen from Gopkuda collected on 15-viii-07 measuring 60 mm. is also without the spot. The black spot behind the opercle is very conspicuous in the specimen from Barkul caught about 18-ix-15. Russel's figure (plate clxxxvi, fig. 1 of vol. ii) does not show the spot nor does his description (p. 70) make any mention of it. Russel considered, probably correctly, his fish to be identical with Willoughby's figure 2, tab. i of his *Ichthyological Appendix*—but as he did not describe the fish and Russel was first to supply the description under Willoughby's name—Russel is the real author of the species for which Willoughby supplied the name and a figure. Russel is not quite sure about the local name of the fish and he gives two alternative names "*Kowal* or *Kowarloo.*" Day gives *Muddecru* as its Telugu name. Russel's local names appear to be of the nature of a generic name for small Clupeioids.

The fish occurs throughout the main area after the freshets. There are altogether four specimens in the collection with the Gopkuda one of 1907.

Distribution :—Seas and estuaries of India, Burma, Siam, Malay Archipelago and Philippines.

Subfamily *ENGRAULINAE.*

Genus ENGRAULIS, Cuvier.

Engraulis annandalei, sp. nov.

(Text-figure 3.)

The dorsal profile is almost straight and the ventral profile is convex from the end of the snout to the origin of the anal fin, from which it is nearly straight to the root of the caudal fin. The shape of the fish is oblong and the body is compressed. The abdominal keel possesses altogether twenty-five scutes beginning from the throat, fifteen of which are preventral and ten behind the root of the ventral fin.

The height (the greatest depth) of the body is 27 %,[1] the length of the head 18·5 % ;

[1] Measurements are in hundredths of the length without the caudal fin.

the least depth of the caudal peduncle 10 %; the length of the maxillary 25·7 %; the length of the pectoral fin 17 %; the length of the ventral fin 9·4 %; the length of the base of the anal fin 38·5 %; the diameter of the eye 5 % and the length of the snout is 3·5 % of the total length.

The snout is prominent, the maxilla is dilated above the mandibulary joint and its posterior tapering portion extends further than the anterior root of the pectoral fin.

The dorsal fin with its two spines and ten rays has an isolated scaly spine anterior to it; there are twenty-five flat scales in front of the dorsal fin, the height of the fin is 17 % of the total length; the origin of the fin is nearer to the end of the snout than to the base of the caudal fin.

The pectoral fin with fourteen rays has a broad appendage attached to the inner side of the root of the fin and is about half its length when it lies flat against the body; the pectoral fin does not reach the root of the ventral fin, and is slightly shorter than the length of the head.

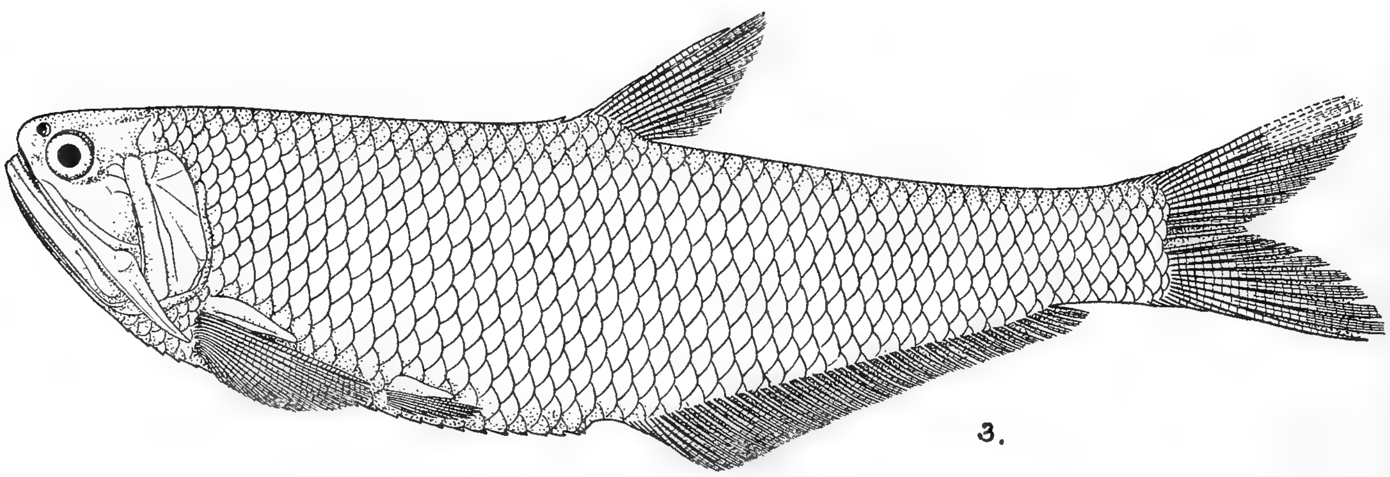


FIG. 3.—*Engraulis annandalei*, Chaudhuri, nat. size.

The ventral fin with its eight rays has also an appendage in its axil which is three-fourths of the length of the fin; the root of the ventral fin is nearer to the origin of the anal fin than the mandibulary joint in the proportion of six to seven.

The anal opening is nearer to the base of the caudal fin than the end of the snout in the proportion of seven to eight, and is not reached by the tips of the ventral fins.

The anal fin has forty-three rays with one or two short compact spines. It commences below the posterior rays of the dorsal fin: the length of the base of the fin is contained $2\frac{5}{9}$ times in the total length (without caudal fin).

The scales are thin but not readily deciduous; the number of scales in the lateral line is fifty and across the body in the line of its greatest breadth thirteen. The colour of the body is silvery with the back slightly dark and the fins hyaline.

This new species is closely related to *E. purava* (H.B.) and *E. mystax* (Bl. and Schn.) but in a good many particulars it differs from both. From *E. purava* (H.B.) it differs in being broader—(the height in *E. purava* being about four whereas in the new

species it is only $3\frac{2}{3}$), and in having a slightly shorter head and larger eye. In *E. purava* the origin of the dorsal fin is midway between the snout and the base of the caudal fin or a little nearer to the base of the caudal, but in the new species the origin of the dorsal fin is nearer to the snout than the root of the caudal fin. The maxillary is slightly longer in the new species than it is in *E. purava*. From *E. mystax* (Bl. and Schn.) the new species differs in having a shorter anal fin, a shorter head, a more prominent snout and in having the origin of the dorsal fin nearer to the snout than to the caudal fin. In *E. mystax* the pectoral fin when laid against the body reaches the root of the ventral fin, whereas in the new species there is some distance between the tip of the pectoral fin and the root of the ventral fin. In *E. mystax* the root of the ventral fin is midway between the mandibulary joint and the anterior root of the anal fin, but in the new species it is nearer to the anterior root of the anal fin. The new species resembles *Engraulis spinifer*, Cuv. et Val., in having the origin of the dorsal fin nearer to the end of the snout than to the base of the caudal fin, but it differs from it in possessing a larger number of scutes, a longer maxillary and in many other important particulars. It resembles *E. valenciennesi* (Blkr.) in having a longer anal fin and in having the origin of that fin a little before the end of the dorsal fin and also in the maxillary reaching slightly beyond the anterior root of the pectoral fin, but differs from it in not having the dorsal profile convex and in not having the origin of the dorsal fin nearer to the base of the caudal than to the snout, in having the pectoral fins not reaching the root of the ventrals and in having a larger number of scutes.

Type.—A specimen 140 mm. long dredged in shallow water on 18-ix-14 off Nalbano Island. It is numbered F$\frac{8781}{1}$ in the Indian Museum register.

Engraulis kempi, sp. nov.

(Text-figure 4.)

The dorsal profile is almost straight as far as the dorsal fin, behind which it is convex; the ventral profile is convex to the anal opening, posterior to which it is somewhat concave. The body is compressed, and the shape is lanceolate. The anterior abdominal edge is provided with twenty-three scutes beginning from the throat, eight of these scutes are post-ventral.

The height of the body is 28 % of the total length, the length of the head 20·5 %, the least depth of the caudal peduncle 10 %, the length of the maxillary 20·5 %, the length of the pectoral fin 19 %, the length of the ventral fin 10 %, the length of the base of the anal fin 32 %, the diameter of the eye 6 % and the length of the snout 5 % in the total length without the caudal fin.

The snout is prominent with a rostro-frontal projection which is rounded. The maxillary is dilated above the mandibulary joint and its posterior tapering portion does not extend beyond the gill-opening.

The dorsal fin has two spines and ten rays with an isolated spine in front and twenty flat scales. The point of origin of the fin is slightly nearer to the snout than to the root of the caudal and its height is 19 % of the total length.

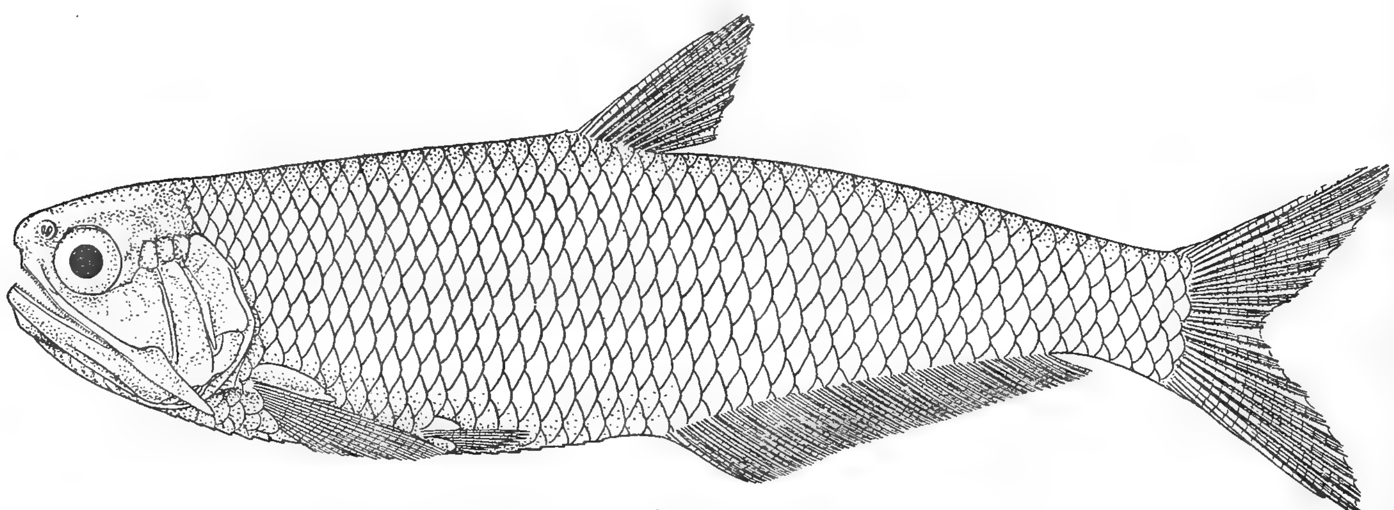
The pectoral fin, which has fourteen rays, reaches beyond the root of the ventral fin, covering almost one-fourth of the length of that fin; there is a broad appendage at the axil of the fin.

The ventral fin, which is also provided with a broad appendage, has eight rays and reaches half the distance that lies between its root and the anal opening. The anal fin has forty rays.

The number of scales in the lateral line is forty-five and there are twelve scales along the line of the greatest breadth.

Colour.—The dorsal side is dark, the middle portion of the body together with the anterior portion of the abdomen silvery, the rest of the body is somewhat pale yellow. The fins are hyaline.

This species differs from *E. annandalei* in having a shorter maxillary which reaches only to the gill-opening, a longer pectoral fin reaching beyond the root of the ventral



4.

FIG. 4.—*Engraulis kempi*, Chaudhuri, × 2.

fin, having a lesser number of scutes, a shorter anal fin, in its shape and both in the dorsal and ventral profile. It resembles *E. valenciennesi* (Blkr.) in having twenty-three scutes and in the pectoral fin reaching the ventrals, but it differs from that species in the dorsal and the ventral profiles, in having longer ventral fins, a shorter maxillary, in having the dorsal fin nearer to the snout and also in proportions.

The *type* specimen, which is 68 mm. in length (without the caudal fin), was caught on 1-iii-14 off Barkul in the main area of the lake and is numbered F $\frac{8782}{1}$ in the Indian Museum register.

There are fifteen co-types of which two were secured on 10-iii-14, eight miles N. E. of Patsahanipur, measuring 64 mm. and 61 mm., thirteen at the same place on 6-iii-14 of which three (measuring 59 to 61 mm.) are pale yellow and the rest (measuring from 46 mm. to 56 mm.) reddish-brown.

The species appears to be a permanent inhabitant of the lake, probably breeding in it.

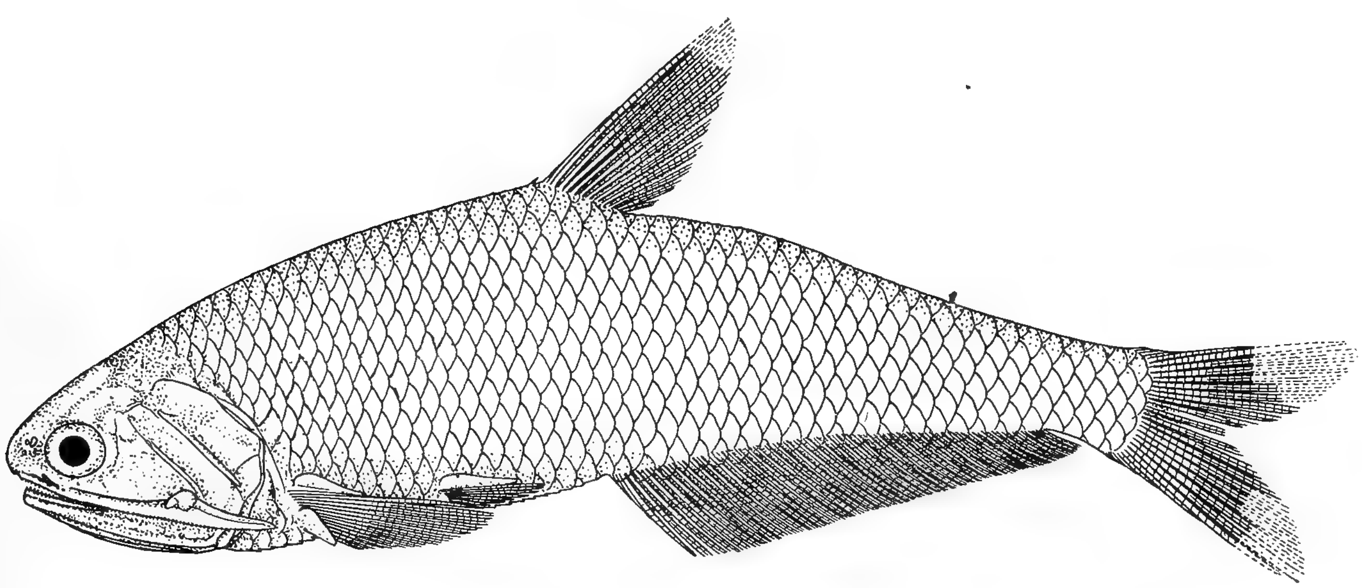
Engraulis rambhae, sp. nov.

(Text-figure 5.)

The dorsal profile is highly convex and the ventral profile is almost straight. The body is compressed. The anterior abdominal edge is provided with twenty-two scutes beginning from the throat, seven of which are post-ventral.

The height of the body is 26 % of the total length, the length of the head 24 %, the least depth of the caudal peduncle 8 %, the length of the maxillary 23 %, the length of the pectoral fin 18 %, the length of the ventral fin 9 %, the length of the base of the anal fin 39 %, the diameter of the eye 6 % and the length of the snout 4 % in the total length without the caudal fin.

The snout is prominent, the maxillary is dilated above the mandibulary joint and



5.

FIG. 5.—*Engraulis rambhae*, Chaudhuri, × $1\frac{1}{3}$.

its posterior tapering portion extends slightly beyond the gill opening, but does not reach the root of the pectoral fin.

The dorsal fin has one spine and ten rays with an isolated spine just in front, the origin of the fin is nearer to the snout than to the base of the caudal fin.

The pectoral fin has thirteen rays and reaches much beyond the root of the ventral fin, covering nearly three-fourths of that fin. The appendage is small and thin.

The ventral fins have seven rays each, the tips of which are at three scales in front of the anal opening. The appendages at their axil are thin and small.

The anal fin has forty rays, the number of scales in the lateral line is forty-six and in the line of the greatest breadth twelve.

Colour.—The dorsal edge is black; the body is silvery with the upper portion yellowish-brown, the lower half of the posterior part is brown and the fins are hyaline.

The highly convex dorsal profile at once distinguishes this species from the rest of the species in the genus most of which have a more or less straight dorsal profile.

It differs also in the number of scutes and in some of its proportions from the other species.

A specimen measuring 100 mm. was caught in Rambha Bay in March, 1914. It is the *type* of the new species and is entered under number F $\frac{8783}{1}$ in the register of the Indian Museum. There are two co-types, one from the same locality as the type measuring 95 mm., and the other (measuring 53 mm.) from off Nalbano, collected on 6-iii-14.

The species is in all probability a permanent inhabitant in the main area and breeds in the lake.

Engraulis purava (H.B.)

1803. *Clupea* sp. (*Pedda Poorawah*), Russel, *Vizag. Fish.*, II, p. 73, pl. cxc.
1822. *Clupea purava*, Hamilton Buchanan, *Fish. Gang.*, pp. 238, 382.
1848. *Engraulis purava*, Cuvier and Valenciennes, *Hist. Nat. Poiss.*, XXI, p. 65.
1878. *Engraulis purava*, Day, *Fish. Ind.*, p. 628, pl. clvii, fig. 2.
1889. *Engraulis purava*, Day, *Faun. Brit. Ind.*, *Fish.*, I, p. 393.

Hamilton Buchanan derived the name of the species from the generic vernacular name quoted by Russel: *Peddah Poorawah*—the great purava. A pair of pear-shaped black markings behind the occiput appears not to have been noticed by Hamilton Buchanan who consequently remarked "No spotting."

There are altogether thirty-four specimens of the species in the collection. This appears to be the prevailing species of the genus in the lake, occurring in all sizes, all over the lake throughout the year. Probably the species breeds in the lake during the rains. The statement below gives the sizes, dates and the different localities in the lake from which specimens were collected.

1	specimen	Off Barnikuda Island	..	6-ix-14,	measuring	85 mm.
3	specimens	Barkul Bay ..	..	21-ix-14,	,,	72 mm. to 112 mm.
2	,,	Off Breakfast Island	..	17-ii-14,	,,	63 mm. and 65 mm.
1	specimen	Chiriya Island towards Samal		8-ii-14,	,,	80 mm.
22	specimens	Kalupara ghat	..	16-ix-14,	,,	from 33 mm. to 65 mm.
2	,,	Kalidai ..	..	8-iii-14,	,,	62 mm and 67 mm.
1	specimen	Nalbano ..	..	25-xi-15,	,,	60 mm.
1	,,	Patsahanipur ..	..	7-iii-14,	,,	49 mm.
1	,,	Off Samal Island	..	22-ix-13,	,,	34 mm.

Distribution:—In the seas and the estuaries of Sind and both sides of India, Rangoon, Penang and the Malay Archipelago.

Engraulis mystax (Bl. and Schn.)

1801. *Clupea mystax*, Bloch and Schneider, *Sys. Ichthyol.*, p. 426.
1849. *Thryssa porova*, Bleeker, *Verh. Bat. Genoots.*, XXII, p. 14.
1867. *Engraulis mystacoides*, Günther, *Cat. Fish. Brit. Mus.*, VII, 396.
1878. *Engraulis mystax*, Day, *Fish. Ind.*, p. 625, pl. clvii, fig. 3.
1889. *Engraulis mystax*, Day, *Faun. Brit. Ind.*, *Fish.*, I, p. 390.
1897. *Trichosoma porava*, Rutter, *Proc. Acad. Nat. Sc. Philadelphia*, p. 65.

Bleeker described a species under the impossible name *E. porova* (*Ich. Madura*, p. 14)—a name very similar to *E. purava* (H. B.). Bleeker's name had been adopted

by Rutter—by whom *E. mystax* was sunk as a synonym of *E. porova*, Blkr., without any justification. Günther rightly concluded that *E. mystax*, *E. porova* and *E. mystacoides*, Blkr., were names for the same species; he, however, selected *E. mystacoides*, sinking the rest of the names believing *E. mystax* (Bl. and Schn.) to be a different species.

There are four specimens in the collection from Rambha Bay, one 80 mm. in length was collected in March 1914, and the rest measuring 66 mm. to 77 mm. were collected on 22-VII-14.

Probably the species is an occasional visitor not breeding in the lake.

Distribution:—Seas and estuaries of India, China, North Celebes, Singapore, Borneo, Sumatra and Java.

Genus **STOLEPHORUS**, Lacépède.

Stolephorus indicus (V. Hasselt).

1803. *Clupea atherinoides*, Russel, *Vizag. Fish.*, II, p. 71, pl. clxxxvii.
1823. *Engraulis indicus*, Van Hasselt, *Algem. Konst-Letterbode*, p. 229, fig. 2.
1872. *Stolephorus indicus*, Bleeker, *Atl. Ich.*, VI, p. 127, t. cclix, fig. 2.
1878. *Engraulis indicus*, Day, *Fish. Ind.*, p. 629, pl. clviii, fig. 3.
1889. *Engraulis indicus*, Day, *Faun. Brit. Ind., Fish.*, I, p. 394.
1914. *Anchovia indica*, Alvin Seale, *Philip. Journ. Sc.*, IX D, p. 59.

This is the most common species of the family in the lake. It is gregarious in habit, planctonic, of small size and translucent when alive. There are altogether five hundred and two specimens in the collection, some of which are young. There are two prevailing colours irrespective of age, size and locality, *viz.*,—reddish-brown and pale yellow.

The following table gives the localities, dates of capture, and the sizes. The species occurs throughout the lake and it appears to be a permanent inhabitant breeding in winter (January and February).

7	specimens	Balugaon	21-vii-13,	measuring from	18 mm. to 23 mm. Colour pale yellow.
1	specimen	Off Barnikuda Island ..	17-ii-14,	,,	60 mm. Col. brown.
13	specimens	S.E. of Barkul bungalow ..	1-iii-14,	,,	25 mm. to 35 mm. Col. pale yellow.
288	,,	From prawn traps and nets at Barkul	21-ix-14,	,,	26 mm. to 56 mm. Col. yellow.
14	,,	Breakfast Island	17-ii-14,	,,	35 mm. to 40 mm. Col. pale yellow.
1	specimen	Chiriya Island	23-ii-14,	,,	38 mm. Col. pale yellow.
3	specimens	S.W. of Kalidai	23-ii-14,	,,	36 mm. to 42 mm. Col. pale yellow.
122	,,	N.E. of Kalidai	5-iii-14,	,,	28 mm. to 47 mm. Col. pale yellow.
10	,,	Do. Do.	Do.	,,	36 mm. to 47 mm. Col. reddish-brown.
4	,,	Do. Do.	Do.	,,	12 mm. to 18 mm. Col. yellow.
7	,,	Off Nalbano Island	6-iii-14,	,,	25 mm. to 42 mm. Col. pale yellow.
1	specimen	S.E. of Patsahanipur ..	28-ii-14,	,,	38 mm. Col. pale yellow.

12	specimens	N.E. of Patsahanipur	..	3-iii-14,	measuring	28 mm. to 45 mm. Col. pale yellow.
5	,,	Do. Do.	..	6-iii 14,	,,	30 mm. to 35 mm. Col. pale yellow.
7	,,	S.E. Do.	..	8-iii-14,	,,	32 mm. to 36 mm. Col. reddish-brown.
3	,,	Rambha Bay	..	February, 1914,	,,	68, 75 and 86 mm. Col. brown.
2	,,	Do.	..	March, 1914,	,,	50 mm. and 53 mm. Col. brown.
1	specimen	Off Samal Island	..	22-ix-13,	,,	35 mm. Col. yellow.
1	,,	Satpara ..	..	..	,,	14 mm. Col. brown.

Distribution:—In seas (ascending rivers) of India, the Malay Archipelago, Philippines, Formosa, Japan, Samoa and Tahiti.

Stolephorus commersonii, Lacépède.

1803. *Stolephorus commersonii*, Lacépède, *Hist. Nat. Poiss.*, V, p. 382, t. xii, fig. 1.
1848. *Engraulis brownii*, Cuvier and Valenciennes, *Hist. Nat. Poiss.*, XXI, p. 41.
1878. *Engraulis commersonii*, Day, *Fish. Ind.*, p. 629, pl. clviii, fig. 1.
1889. *Engraulis commersonii*, Day, *Faun. Brit. Ind.*, *Fish.*, I, p. 394.

There are altogether eight specimens in the collection, all of adult size, obtained during the months of February and March, in the main area of the lake. Probably the species is only an occasional visitor during the period of maximum salinity of the water of the lake. It does not appear to have bred in the lake.

1	specimen	Off Barkul Bay	..	1-iii-14,	measuring	37 mm.
1	,,	Kalidai ..	..	21-ii-14,	,,	42 mm.
2	specimens	South of Kalidai	..	2-iii-14,	,,	32 and 37 mm.
2	,,	S. W. Do.	..	March 1914,	,,	36 and 42 mm.
2	,,	S. E. of Patsahanipur	..	9-iv-15,	,,	35 and 40 mm.

Distribution:—Seas of India, of the Malay Archipelago, Philippines and also of Madagascar.

Stolephorus tri, Bleeker.

1852. *Engraulis tri*, Bleeker, *Verh. Bat. Genoots.*, XXIV, p. 40.
1872. *Stolephorus tri*, Bleeker, *Atl. Ich.*, VI, p. 128, t. cclxii, fig. 1.
1878. *Engraulis tri*, Day, *Fish. Ind.*, p. 630, pl. clviii, fig. 6.
1889. *Engraulis tri*, Day, *Faun. Brit. Ind.*, *Fish.*, I, p. 395.

Only one specimen is in the collection; it is of adult size and was obtained from Rambha Bay in the month of February, 1914. The colour of the body is reddish-brown with a longitudinal silvery band in the middle. Probably an occasional visitor to the lake.

Distribution:—The seas and estuaries (ascending rivers) of India, Malay Archipelago and Philippines.

Subfamily *CLUPEINAE*.

Genus **CLUPEOIDES,** Bleeker.

Clupeoides lile (Cuvier and Valenciennes).

1847. *Meletta lile*, Cuvier and Valenciennes, *Hist. Nat. Poiss.*, XX, p. 378.
1850. *Alausa champil*, Cantor, *Journ. As. Soc. Bengal*, XVIII, p. 1284.

1878. *Clupea lile*, Day, *Fish. Ind.*, p. 638, pl. clxii, fig. 1.
1889. *Clupea lile*, Day, *Faun. Brit. Ind., Fish.*, I, p. 374.

There are altogether twenty-six specimens in the collection of which only one was obtained in the month of July near Samal Island; the rest were caught in the main area during the months of February and March, in which period the water of the lake becomes as salt as that of the Bay outside. Probably the species is a seasonal visitor during the season of maximum salinity. It does not breed in the lake, from which it has been previously reported. The following statement will show the different localities from which the specimens were collected and their number and sizes :—

1	specimen	Off Barkul Bungalow ..	1-iii-14,	measuring	46 mm.
1	,,	Do. ..	3-iii-14,	,,	50 mm.
1	,,	Do. ..	?	,,	53 mm.
4	specimens	N.W. of Breakfast Island	17-ii-14,	,,	48 mm. to 54 mm.
1	specimen	Between Domkuda and Samal I.	18-vii-14,	,,	58 mm.
2	specimens	N.E. of Kalidai ..	5-iii-14,	,,	45 mm.
1	specimen	N.E. of Patsahanipur ..	3-iii-14,	,,	53 mm.
1	,,	S.E. Do. ..	6-iii-14,	,,	50 mm.
1	,,	N.E. Do. ..	7-iii-14,	,,	53 mm.
1	,,	Two miles S.E. of Patsahanipur	8-iii-14,	,,	54 mm.
4	specimens	Eight miles N.E. Do.	10-iii-14,	,,	42-50 mm.
7	,,	Rambha Bay	2-ii-14,	,,	42-62 mm.
1	specimen	Do.	14-ii-14,	,,	54 mm.

Distribution:—In the sea, along the West Coast of India, Ceylon, Burma, Siam, and the Malay Archipelago.

Genus CLUPEA, Linnaeus.

Clupea ilisha (Hamilton Buchanan).

1803. *Clupea* sp. (*Palashah*), Russel, *Vizag. Fish.*, II, p. 77, pl. cxcviii.
1822. *Clupanodon ilisha*, Hamilton Buchanan, *Fish. Gang.*, pp. 243, 382, pl. xix, fig. 93.
1878. *Clupea ilisha*, Day, *Fish. Ind.*, p. 640, pl. clxii, fig. 3.
1889. *Clupea ilisha*, Day, *Faun. Brit. Ind., Fish.*, I, p. 376, fig. 115.

There is a specimen in the collection, caught at Barkul in the month of September, 1914, which is 322 mm. in length. Another specimen, 360 mm. in length, which was obtained by netting near Kalidai on the 14th January, 1907, was kept alive for over six hours in an earthen pot. Hence the general belief that *C. ilisha* always dies immediately on capture is not true—at least of the Chilka race.[1] Probably the high salinity of the water in January might have had something to do with the prolongation of life after capture. The occurrence of *C. ilisha* in the lake throughout the year and the fact of its not dying off immediately after capture, as well as the comparative freshness of the water of the lake soon after freshets, should prove to be sufficient inducement to practical pisciculturists to attempt 'stripping' *C. ilisha* in the lake, though it must remain doubtful if the species breeds there.

Distribution :—The coasts of India, including Sind and Burma, passing up the

[1] *Journal Bengal Fisheries* (1907), p. 94, para. 329.

large rivers to breed, the Persian Gulf ascending the Tigris, and the coast of Siam entering lakes.

Suborder *OSTARIOPHYSI.*

Family SILURIDAE.

Subfamily *CLARIINAE.*

Genus **PLOTOSUS**, Lacépède.

Plotosus canius, Hamilton Buchanan.

1803. *Platystacus anguillaris*, Russel, *Vizag. Fish.*, II, p. 51.
1822. *Plotosus canius*, Hamilton Buchanan, *Fish. Gang.*, pp. 142, 374, pl. xv, fig. 44.
1878. *Plotosus canius*, Day, *Fish. Ind.*, p. 482, pl. cxii, fig. 3.
1889. *Plotosus canius*, Day, *Faun. Brit. Ind., Fish.*, I, p. 113, fig. 47.

Russel mentions two specimens, one of which was caught in a river, measuring two feet and seven inches in length, and the other, which was obviously caught in the open sea and was the original for Russel's plate no. clxvi, measuring seven inches in length. The latter was undoubtedly a specimen of *Plotosus anguillaris* (Bloch) which is a marine species, but the former from its size as well as from its estuarine character must have been a specimen of *Plotosus canius*, H.B., which Russel described under the name *P. anguillaris*, Bloch.

There are altogether twenty-eight specimens in the collection from different parts of the lake, obtained throughout the year. Young specimens were mainly obtained after the rains in the outer channel. The following list indicates roughly the distribution of the species in the lake.

2	specimens	Channel north of Arupátná (south side of Satpara) ..	10-ix-14,	measuring	60 mm. and 28 mm.
2	,,	Barkul Point	21-ix-14,	,,	256 mm. and 250 mm.
1	specimen	Off Mahosa	12-ix-13,	,,	27 mm.
4	specimens	Between Samal Island and Mainland	10-ix-14,	,,	76 mm. to 80 mm.
2	,,	Satpara	March 1914,	,,	283 mm. to 316 mm.
2	,,	Off Satpara	17-ix-13,	,,	42 mm. and 120 mm.
13	,,	Serua Nadi (depth 5ft. to 9ft.) .. .	18-ix-14,	,,	33 mm. to 68 mm.
2	,,	South-eastern corner of the lake	?	,,	485 mm. and 496 mm.

In every specimen there is an anal papilla, which is tubular and elongated, immediately behind the vent. It is enclosed from behind by a large spongy and arborescent (dendritic) organ. In very young specimens this arborescent organ appears to look like a gill-book-form of respiratory organ. The whole of it is covered over by the ventral fins, which extend beyond it over-lapping a portion of the anal fin. The ventral fins thus probably protect the organ from mud, on which the fish usually rests, being a bottom fish. The arborescent organ would be soon choked with mud if not thus protected. The function of the organ is evidently respiratory and not sexual as it is found fully formed even in very young specimens.

Distribution:—In the sea, brackish waters and rivers of India, Ceylon, Andaman Islands, the Malay Archipelago and Celebes.

Subfamily *SILURINAE*.

Genus **WALLAGO**, Bleeker.

Wallago attu (Bloch and Schneider).

1801. *Silurus attu*, Bloch and Schneider, *Syst. Ichthyol.*, p. 378.
1803. *Silurus* sp. (*wallago*), Russel, *Vizag. Fish.*, II, p. 50, pl. clxv.
1822. *Silurus boalis*, Hamilton Buchanan, *Fish. Gang.*, pp. 154 and 375, pl. xxix, fig. 49.
1862. *Wallago attu*, Bleeker, *Atl. Ichth.*, II, p. 79, tab. lxxxvi, fig. 1.
1878. *Wallago attu*, Day, *Fish. Ind.*, p. 479, pl. cxi, fig. 4.
1889. *Wallago attu*, Day, *Faun. Brit. Ind.*, *Fish.*, I, p. 126, fig. 54.

Only one specimen, comparatively young, measuring 253 mm., was collected, at Barkul in September, 1914. The fleshy and triangular anal papilla lies horizontally in a groove behind the anal opening and the ventral fins extend to the first few rays of the anal fin entirely covering the papilla.

This fish appears to be an occasional visitor to the main area after freshets.

Distribution:—Fresh waters throughout India, Ceylon, Siam and the Malay Archipelago. The fish is occasionally found within tidal influence.

Genus **CALLICHROUS**, Hamilton Buchanan.

Callichrous bimaculatus (Bloch).

1794. *Silurus bimaculatus*, Bloch, *Ausl. Fisch.*, VIII, p. 24.
1822. *Silurus* (*Callichrous*) *canio*, Hamilton Buchanan, *Fish. Gang.*, pp. 151, 375.
1842. *Silurus indicus*, McClelland, *Cal. Journ. Nat. Hist.*, II, p. 583.
1841. *Schilbe pabo*, Sykes, *Trans. Zool. Soc.*, II, p. 367.
1878. *Callichrous bimaculatus*, Day, *Fish. Ind.*, p. 476, pl. cx, figs. 4 and 5.
1889. *Callichrous bimaculatus*, Day, *Faun. Brit. Ind.*, *Fish.*, I, p. 131, fig. 57.

One specimen, measuring 231 mm., was obtained at Barkul in the month of September, 1914. Evidently it entered the lake from some river during the floods.

Distribution:—Fresh waters of India, Ceylon, Siam and the Malay Archipelago. The fish has been also found within tidal influence in Burma.

Genus **PANGASIUS**, Cuvier and Valenciennes.

Pangasius pangasius (Cuvier and Valenciennes).

1822. *Pimelodus pangasius*, Hamilton Buchanan, *Fish. Gang.*, pp. 163 and 376, pl. xxxiii, fig. 52.
1840. *Pangasius buchanani*, Cuvier and Valenciennes, *Hist. Nat. Poiss.*, XV, p. 45.
1878. *Pangasius buchanani*, Day, *Fish. Ind.*, p. 470, pl. cviii, fig. 5.
1889. *Pangasius buchanani*, Day, *Faun. Brit. Ind.*, *Fish.*, I, p. 142, fig. 61.

Two young specimens, measuring 104 mm. and 85 mm. respectively, were collected about eight miles south-east of Kalupara Ghat on the 16th September, 1914. They evidently came to the lake along with the freshets. There is a thick anal papilla

lying alongside the body behind the anal opening. The tips of the ventral fins reach the anterior edge of the anal opening in both specimens.

The species is a flood-time visitor to the lake when the water is almost fresh.

Distribution :—Large rivers and estuaries of India and the Malay Archipelago.

Genus **OSTEOGENEIOSUS**, Bleeker.

Osteogeneiosus militaris (L.)

1758. *Silurus militaris*, Linnaeus, *Syst. Nat.*, Edit. X, p. 305.
1850. *Arius militaris*, Cantor, *Journ. Asiat. Soc. Bengal*, XVIII, p. 1241.
1858. *Osteogeniosus cantoris*, Blyth, *Proc. Asiat. Soc. Bengal*, p. 286.
1878. *Osteogeniosus militaris*, Day, *Fish. Ind.*, p. 469, pl. cviii, fig. 4.
1889. *Osteogeniosus militaris*, Day, *Faun. Brit. Ind., Fish.*, I, p. 190, fig. 69.

Two adult specimens of the species are in the collection, one measuring 260 mm., from Parikudh, collected on 29-xi-14 and the other measuring 240 mm. from Barkul, obtained on 28-xi-14.

This fish probably is not a permanent inhabitant of the lake, nor does it appear to breed in it. It is a visitor to the main area during the winter months when the water is fairly saltish.

Distribution :—The seas, estuaries and tidal rivers of India and the Malay Archipelago.

Subfamily *BAGRINAE*.

Genus **ARIUS**, Cuvier and Valenciennes.

Arius satparanus, sp. nov.

(Text-figures 6—8.)

The body is elongated and round but compressed in the region of the caudal peduncle.

The measurements in hundredths of the length without the caudal fin are as follows: the length of the head 28·6 %, the greatest depth of the body 20 %, the length of the snout 12 %, the diameter of the eye 4·76 %, the length of the pectoral fin 19 %, and the length of the ventral fin 14·3 %.

The head is somewhat depressed, and is broader than high. The median fontanel is rather narrow and short, beginning from behind the nostrils to the occipital process, which is granular and rugose. The occipital process continues to the basal bone of the dorsal spine (text-fig. 7). The dorsal profile, from the dorsal spine to the slightly prominent snout, slopes down in a somewhat convex line.

The eye is oval, the vertical diameter being 80 % of the length of the horizontal diameter ; the orbital margin is not entirely free, being continuous with the skin of the forehead in one-fourth of its upper margin in the middle.[1] The longer diameter of the

[1] "Eyes with free orbital margins" is stated to be one of the generic characters of *Arius*. In the specimen under description one-fourth of the upper margin about the middle of the eye is not free, but is continuous with the skin of the forehead. Instead of founding a new genus or subgenus on this difference, the description for the genus should be modified to allow this species to be included.

eye is contained two and a half times in the length of the snout and three and a half times in the length of the interorbital distance.

The barbels are rather short; the maxillary barbels are three-fourths of the length of the head, the mandibular pair is as long as the interorbital distance and the mental pair is as long as the snout.

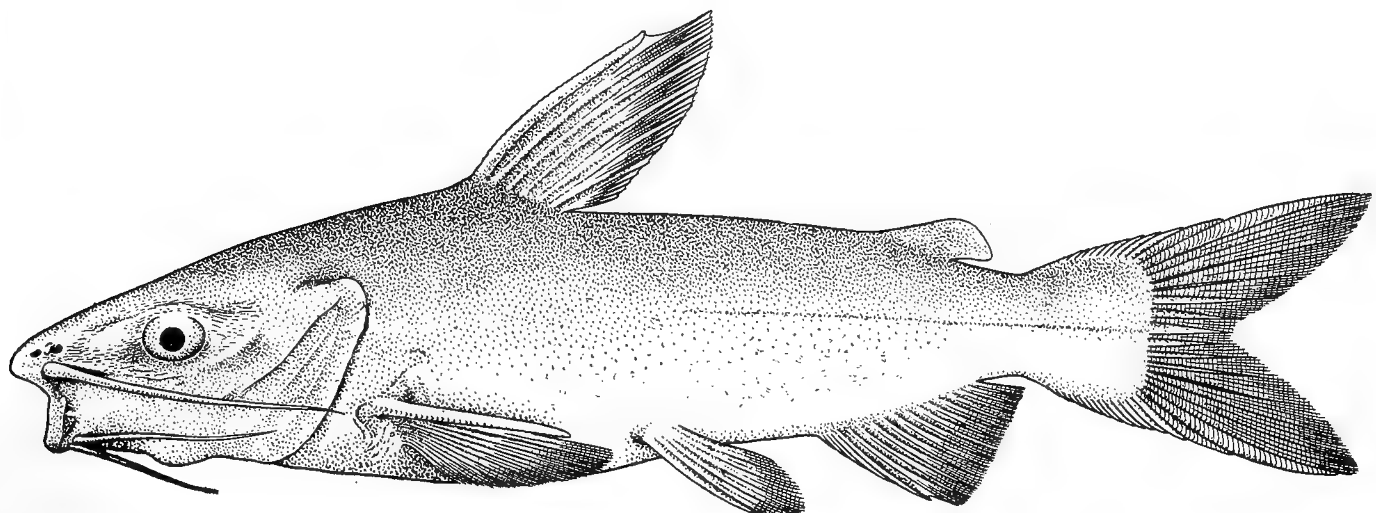


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FIG. 6.—*Arius satparanus*, Chaudhuri, × $\frac{2}{3}$.

The dorsal fin has one spine and six rays, the spine is feebly serrated behind and granulated in front. The height of the fin is equal to the length of the maxillary barbels and the length of the spine is about 80 % of the height of the fin. The base of the adipose dorsal fin is two-thirds of its length and is contained ten and a half times in the distance between the two dorsal fins.

The pectoral fin contains one spine and ten rays and does not reach the ventral fin. The spine is somewhat flattened and is serrated both ways. The ventral fin has six rays, the outer one of which is articulated. It is three-fourths the length of the pectoral, and the vent is just above the middle of the fin when it lies horizontally along the body. The anal fin has nineteen rays, a few of the anterior rays are in front of the vertical line from the origin of the adipose dorsal. The caudal fin is deeply forked with rounded lobes, the upper being slightly longer than the lower portion.

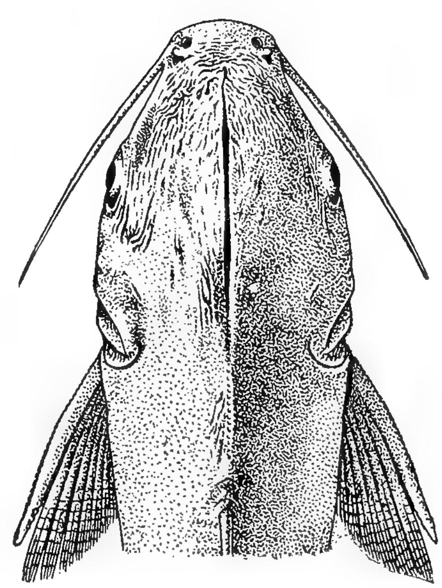

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FIG. 7.—*Arius satparanus*, Chaudhuri, × $\frac{2}{3}$.
Dorsal view of the head.

The teeth in the jaws are villiform, in the upper jaw the space covered with these teeth is divided into two equal ellipsoidal areas with a separating line in the middle. In the lower jaw the space is divided into two short and narrow arcuate areas with a broad toothless space in the middle. The palatine teeth are granular and occur in two

somewhat oval patches far backward on the roof of the mouth (text-fig. 8). There are fifteen gill-rakers which are short and stiff.

The colour of the fish (in spirit) in the upper part is dark brown tinged with blue; the lower part of the sides and the abdomen are dull white. The margins of the dorsal and caudal fins are black.

The new species resembles *Arius arius* (Ham. Buch.) and also *A. maculatus* (Thunberg) in general appearance, but differs from both in the character of the teeth, the length of the barbels and fins, as well as in the structure of the orbital margin; this margin is not free, but is continuous in the middle with the skin of the forehead above.

Type.—A specimen 210 mm. long, dredged in six and a half feet of water in the channel between Satpara and Barnikuda, on 4-ix-14. It is entered in the Indian Museum register under No. F $\frac{8784}{1}$.

Arius arius (Hamilton Buchanan).

(Text-figure 9.)

1822. *Pimelodus arius*, Hamilton Buchanan, *Fish. Gang.*, pp. 170 and 376.
1878. *Arius buchanani*, Day, *Fish. Ind.*, p. 463, pl. cv, fig. 6.
1889. *Arius buchanani*, Day, *Faun. Brit. Ind.*, *Fish.*, I, p. 181.

One young specimen, measuring 185 mm., obtained on 2-ix-14 in the channel off Satpara, is in the collection. The horizontal diameter of the eye is 22 % in the length of the head, while in the adult it is 18 % to 13 %. The anal papilla has a wide lumen with a thin fimbriated edge. The species is quite distinct from *A. maculata* (Thunberg), which has longer barbels, different proportions, colouration and dentition (text-fig. 9).

Probably this species is a permanent inhabitant of the outer channel.

Distribution:—The estuaries of Bengal, Orissa and Burma.

Arius caelatus, Cuvier and Valenciennes.

(Text-figure 10.)

1840. *Arius caelatus*, Cuvier and Valenciennes, *Hist. Nat. Poiss.*, XV, p. 66.
1878. *Arius caelatus*, Day, *Fish. Ind.*, p. 459. pl. cv, fig. 5.
1889. *Arius caelatus*, Day, *Faun. Brit. Ind.*, *Fish.*, I, p. 174.

There are two specimens in the collection. One is a young fish measuring 125 mm. caught north of Patsahanipur on 3-iii-14, the other is an adult fish measuring 245 mm. secured off Barkul Point on 27-xi-14. The ventral fins are situated far backwards in both specimens, almost reaching the anal fin, the anal opening being above the middle of the ventral fin. The anal papilla is rather inconspicuous. In the upper jaw the villiform teeth are in a broad arcuate band of almost uniform breadth, occupying only the middle half of the whole jaw and without any dividing line or empty space in the middle. They are very unlike the villiform teeth of the lower jaw—which are situated in two divided horn-shaped areas with a smooth space in the middle of the jaw, with their broad ends towards the middle. The teeth on the palate are also villiform. They occur in two triangular patches not very far from

the upper jaw, the bases of these triangular areas being turned towards the upper jaw, with the apices towards the centre of the upper palate (text-fig. 10).

The species appears to be a permanent inhabitant in the main area of the lake, probably breeding in it.

Distribution:—In seas, rivers, and brackish waters of Bombay, Madras, Orissa, Bengal, Burma, Siam and the Malay Archipelago.

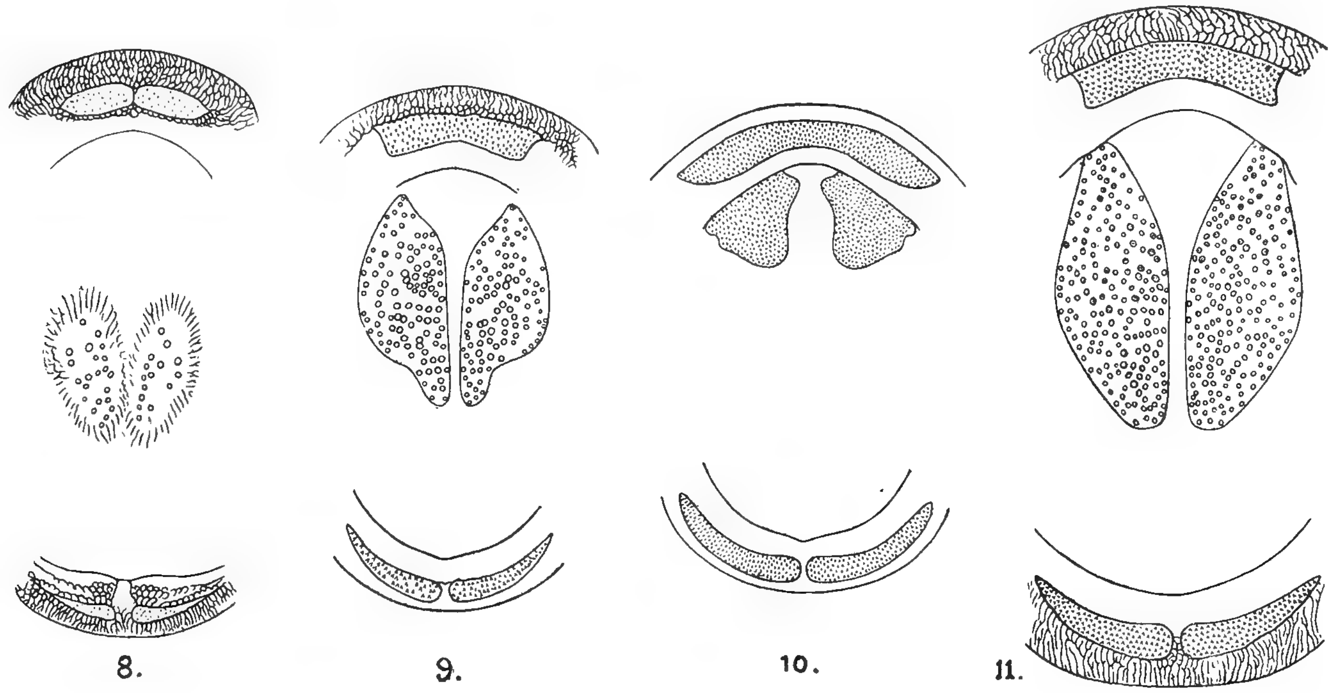

FIG. 8.—*Arius satparanus*, Chaudhuri.
Teeth of upper jaw, palate and lower jaw.

FIG. 9.—*Arius arius* (Hamilton Buchanan).
Teeth of upper jaw, palate and lower jaw.

FIG. 10.—*Arius cœlatus*, Cuvier and Valenciennes.
Teeth of upper jaw, palate and lower jaw.

FIG. 11.—*Arius falcariu*, Richardson.
Teeth of upper jaw, palate and lower jaw.

Arius falcarius, Richardson.

(Text-figure 11.)

1844. *Arius falcarius*, Richardson, *Zool. Voy. Sulph. Fish*, p. 134, pl. 62, figs. 7-9.
1846. *Arius falcarius*, Richardson, *Rep. Ichthy. Sea. Chin. Jap.*, p. 284.
1866. *Arius falcarius*, Günther and Playfare, *Fish. Zanzib.*, p. 114.
1878. *Arius falcarius*, Day, *Fish. Ind.*, p. 463, pl. cvi, fig. 5.
1889. *Arius falcarius*, Day, *Faun. Brit. Ind.*, *Fish.*, I, p. 182.

There is one adult specimen in the collection measuring 384 mm., captured near Barkuda Island inside the lake on 6-ix-14, in five and a half feet of water.

The villiform band of teeth in the upper jaw is equally wide throughout and does not reach the angles of the jaw, nor is there a dividing line in the middle. The palatine teeth are in two elongated patches, close and running parallel to the middle line—the anterior teeth are granular and the posterior globular. The villiform teeth in the lower jaw are divided by a smooth mesial line into two elongated arcuate

bands, broad towards the mesial line and tapering to a point towards the angle of the jaw, the two taken together being much longer than the band of teeth in the upper jaw (text-fig. 11).

Probably a casual visitor to the lake.

Distribution:—Seas of India and China, and East Africa. A variety of this species occurs in Africa.

Genus MACRONES, Duméril.

Macrones cavasius (Hamilton Buchanan).

1822. *Pimelodus cavasius*, Hamilton Buchanan, *Fish. Gang.*, pp. 203 and 379, pl. xi, fig. 67.
1841. *Pimelodus seengtee*, Sykes, *Trans. Zool. Soc.*, II, p. 374, t. lxvi, fig. 2.
1865. *Hypselobagras cavasius*, Day, *Fish. Malab.*, p. 188.
1878. *Macrones cavasius*, Day, *Fish. Ind.*, p. 447, pl. c, fig. 1.
1889. *Macrones cavasius*, Day, *Faun. Brit. Ind., Fish.*, I, p. 155.

One specimen from Barkul secured in September, 1914, measuring 85 mm., is in the collection. It evidently entered the lake from neighbouring fresh waters during the floods and is only a chance visitor when the water is entirely fresh.

Distribution:—In fresh waters of Sind, Southern India, Bengal, Assam and Burma.

Macrones gulio (Hamilton Buchanan).

1822. *Pimelodus gulio*, Hamilton Buchanan, *Fish. Gang.*, pp. 201 and 379, pl. xxiii, fig. 66.
1849. *Bagrus abbreviatus*, Cantor, *Journ. Asiat. Soc. Bengal*, XVIII, p. 1236.
1878. *Macrones gulio*, Day, *Fish. Ind.*, p. 445, pl. xcix, fig. 2.
1889. *Macrones gulio*, Day, *Faun. Brit. Ind., Fish.*, I, p. 151, fig. 64.

There are altogether forty-five specimens of this species in the collection, from different parts of the lake; they are of all sizes as shown in the list given below. In all the specimens no anal papilla proper is found, but in its place, that is at a distance of one diameter of the eye behind the vent, there is a pore edged with a thick fimbriated muscular margin. The ventral fins almost reach the anal fin. The colouration of the pectoral, ventral, anal and caudal fins is very variable, in some they are black all over, in others the superior sides of the paired fins are quite white, in still others only the tips of some of these fins are black and the rest white; sometimes the tips of the anal or the ends of the caudal fins only are black.

The fish is a permanent inhabitant of the lake and breeds freely in it. It is more numerous in the outer channel and probably is replaced by *Macrones vittatus* (Bloch.) in the north-east corner of the main area where freshwater channels enter the lake.

The following list of the catch will roughly show the distribution of the species in the lake :—

1	specimen	Off mouth of Barkul Bay ..	18-ix-14,	measuring	45 mm.
1	,,	Nalbano Island	25-xi-14,	,,	58 mm.
1	,,	Parikudh	28-ix-14,	,,	81 mm.

8	specimens	Rambha	.. 19-xi-14,	measuring	87 to 123 mm.
2	,,	Rambha Bay ..	February, 1914,	,,	79 mm. and 85 mm.
23	,,	Satpara	March, 1914,	,,	44 mm. to 85 mm.
3	,,	Do.	September, 1913,	,,	22 mm., 24 mm. and 26 mm.
1	specimen	South-eastern corner of the lake	..	,,	170 mm.
2	specimens	South end of the lake ..	21-31-vii-13,	,,	89 mm. and 111 mm.

Distribution :—Seas, estuaries and tidal waters of Sind, Bombay, Madras, Orissa, Bengal, Assam and Burma; also of Ceylon and the Malay Archipelago.

Macrones vittatus (Bloch).

1785. *Silurus vittatus*, Bloch, *Ausl. Fisch.*, t. ccclxxi, fig. 2.
1801. *Silurus vittaus*, Bloch and Schneider, *Syst. Ichthy.*, p. 387.
1822. *Pimelodus carcio*, Hamilton Buchanan, *Fish. Gang.*, pp. 181 and 377.
1842. *Pimelodus indicus*, McClelland, *Cal. Journ. Nat. Hist.*, II, p. 584.
1849. *Bagrus affinis*, Jerdon, *Mad. Journ. Lit. Sc.*, XV, p. 338.
1878. *Macrones vittatus*, Day, *Fish. Ind.*, p. 448, pl. xcviii, fig. 3, and pl. xcix, fig. 4.
1889. *Macrones vittatus*, Day, *Faun. Brit. Ind., Fish.*, I, p. 157.

There are altogether thirty-five specimens of this species in the collection all from the main area of the lake. The species appears to be restricted more to the western edge and the north-western corner of the lake as the distribution list given below will show :—

7	specimens	Off Barnikuda	6-ix-14,	measuring	40 mm. to 60 mm.
11	,,	Near Barnikuda (inside lake)	6-ix-14,	,,	55 mm. to 70 mm.
5	,,	Barkul (Prawn traps)	21-ix-14,	,,	44 mm. to 80 mm.
3	,,	Off Kalupara ghat (1½ miles)	15-ix-14,	,,	37 mm. to 57 mm.
9	,,	About eight miles south-east of Kalupara ghat	16-ix-14,	,,	38 mm. to 58 mm.

This freshwater *Macrones* in all probability breeds in the lake after the rains. It is not a casual visitor like the other freshwater *Macrones, i.e., Macrones cavasius* (H.B.), of which there is only one specimen in the collection.

In the specimens of *M. vittatus* the ventral fin reaches the anal fin and the anal papilla is more often present than not. The tips of the caudal fin are black and the rest of the fin white. It is a much smaller fish than *Macrones gulio* (H.B.) which is the most numerous *Macrones* in the lake.

Distribution :—Throughout the fresh waters of India, Ceylon, Siam and Tranquebar.

Family CYPRINIDAE.

Subfamily *CYPRININAE*.

Genus **CIRRHINA**, Cuvier.

Cirrhina latia (Hamilton Buchanan).

1822. *Cyprinus latius*, Hamilton Buchanan, *Fish. Gang.*, pp. 345 and 393.
1822. *Cyprinus gohama*, *id.*, *ibid.*, pp. 346 and 393.
1838. *Barbus diplochilus*, Heckle, *Fische aus Kasmir*, p. 53, t. x, fig. 1.

1839. *Gonorhynchus fimbriatus*, McClelland, *Asiat. Researches*, XIX, pp. 282 and 375, pl. xliii, fig. 3 B.
1839. *Gonorhynchus macrosomus*, *id.*, *ibid.*, pp. 282 and 372, pl. xliii, fig. 7 B.
1839. *Gonorhynchus gohama*, *id.*, *ibid.*, p. 283, pl. xliii, fig. 6 B.
1839. *Gonorhynchus brevis*, *id.*, *ibid.*, p. 373.
1841. *Chondrostoma wattanah*, Sykes, *Trans. Zool. Soc.*, II, p. 360, pl. lxii, fig. 4.
1872. *Crossocheilus barbatulus*, Beavan, *Proc. Zool. Soc.*, p. 152, fig. 2.
1878. *Cirrhina latia*, Day, *Fish. Ind.*, p. 548, pl. cxxx, fig. 4.
1889. *Cirrhina latia*, Day, *Faun. Brit. Ind.*, *Fish.*, I, p. 279.

There is only one specimen, secured on 4-i-15 at Barkul and measuring 89 mm. The maxillary barbels are wanting. This is a strictly freshwater species. Its occurrence in the lake, especially in the beginning of January (when the water is very salt) is most extraordinary. This must have been one of those rare occasions on which a freshwater fish had entered the lake through one of the numerous streams or flood overflows and had survived at the edge of the lake at a place where the inflow drainage water had enabled it to shift for a time.

Distribution:—Fresh waters along the foot of the Himalayas, and of the United Provinces, Punjab, Sind, Deccan, Orissa, Bengal and Assam.

Genus **BARBUS**, Cuvier.

Barbus sophore (Hamilton Buchanan).

1822. *Cyprinus sophore*, Hamilton Buchanan, *Fish. Gang.*, pp. 310 and 389, pl. xix, fig. 86.
1839. *Cyprinus sophore*, McClelland, *Asiat. Researches*, XIX, pp. 285 and 382.
1842. *Cyprinus sophore*, Cuvier and Valenciennes, *Hist. Nat. Poiss.*, XVI, p. 388.
1844. *Leuciscus stigma*, *id.*, *ibid.*, XVII, p. 93, pl. cccclxxxix.
1844. *Leuciscus duvaucelii*, *id.*, *ibid.*, XVII, p. 95, pl. ccccxci.
1844. *Leuciscus sulphureus*, *id.*, *ibid.*, XVII, p. 96.
1849. *Systomus sophore*, Jerdon, *Madr. Journ. Lit. Sc.*, XV, p. 316.
1867. *Puntius modestus*, Kner, *Novara Fische*, p. 348, t. xv, fig. 3.
1868. *Puntius stigma*, Day, *Proc. Zool. Soc.*, p. 198.
1868. *Barbus sophore*, Gunther, *Cat. Fish. Brit. Mus.*, VII, p. 152.
1869. *Barbus (Puntius) stigma*, Day, *Proc. Zool. Soc.*, p. 375.
1878. *Barbus stigma*, Day, *Fish. Ind.*, p. 579, pl. cxli, fig. 5.
1889. *Barbus stigma*, Day, *Faun. Brit. Ind.*, *Fish.*, I, p. 329.

There are altogether forty-six specimens of various sizes in the collection obtained at different times of the year in the main area of the lake. The largest number was obtained after the floods.

Hamilton Buchanan gave the name "*Cyprinus sophore*" to this fish, the specific name being derived, as he says, from its Sanskrit equivalent; he found this fish to be a "beautiful little fish," "very common in ponds" in Bengal. He definitely stated in the text that the fish so named by him was represented by figure 86 of plate xix of his illustrations that were published along with the text of his work on the *Fishes of the Ganges*.

In the introductory remarks in English there were two or more 'printer's mistakes.' In the first para. of his introductory remark he stated that there were only

two black spots, "one at the end of the tail (caudal peduncle) and another at the root of the dorsal fin"—a few lines below in the second para. he says "besides the five spots mentioned in the specific character" (p. 310). This *five* is obviously a misprint for *two*. In the third para. he makes another obvious mistake by stating "there are four tendrils, so very minute, as often to be scarcely perceptible" (p. 311). The figure in the illustration which he specially refers to in the text does not show any trace of barbels whatever, nor in his *Index Methodicus* (synoptical table, 42) which follows the introductory remarks in English, and which contains brief scientific descriptions in Latin of all the species,—do the barbels find any place (p. 389). Therefore the statement as to four minute barbels must also be regarded as a mistake or oversight. McClelland, Cuvier, Valenciennes, and Günther all took up this position and decided that the species *C. sophore* described by Hamilton Buchanan was the little *Barbus* without barbels so common in the ponds of Bengal. Day, however, disputed this point, and he thought that by the name *C. sophore* Hamilton Buchanan described a *Barbus* with four barbels and the name should be restricted to some fish which must have four barbels even if it had no resemblance to the figure nor any reference to other portions of his description. In going over the collection of fish in the Museum of the Asiatic Society of Bengal, Day came across one "bleached" specimen of a small *Barbus* with four barbels, but without any name or label for locality or donor. This Day at once concluded to be a typical specimen of *C. sophore* in spite of its long barbels and colourless condition,[1] and when twelve other small *Barbus* (some of which were undoubtedly young—their lengths without the caudal fin varying from 24 mm. to 58 mm.) similar to the bleached specimen came to the Museum from the Khasia Hills, forwarded by Mr. R. Bevan,[2] Day at once concluded that the bleached fish without a label must have come from the Khasia Hills! He also concluded that this was the *Cyprinus sophore* of Hamilton Buchanan. In arriving at this conclusion Day entirely disregarded the fact that Hamilton Buchanan's *C. sophore* was "very common in ponds" in Bengal. The Khasia species has rather long barbels and the colouration and proportions are different; it is a comparatively rare species and even according to Day is to be found only in "Assam and Khasia Hills" (*Faun. Brit. Ind., Fish.*, I, p. 309). Thus disregarding the conclusions of Cuvier, McClelland, Günther and others, Day wanted to apply the name *sophore* to a very rare species of *Barbus* from Assam, a species with four long barbels and of a very different colouration from that given by Hamilton Buchanan for his *sophore*.

There is another specimen in the collection of the Indian Museum[3] purchased from Day on the 8th September, 1879, which is labelled "*Barbus sophore* (H.B.)" in Day's own handwriting. The locality of this specimen is given by Day as Basein, Burma. It has only two maxillary barbels and is without any dark

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[1] This specimen is in the collection of the Indian Museum numbered No. F $\frac{5484}{1}$ in the register of the Museum. Its total length without the caudal fin is 86 mm.

[2] These specimens are numbered F $\frac{5489}{1}$ to F $\frac{5500}{1}$ in the register of the Indian Museum.

[3] This specimen is numbered 2734 in the register of the Indian Museum.

spots and measures 117 mm. in length without the caudal fin. This specimen also cannot be said to have anything to do with "the beautiful little fish very common in ponds" to which Hamilton Buchanan gave the name. Thus Day used the name "*sophore*" of Hamilton Buchanan for two very different fishes—one from the Khasia Hills and the other from Burma. Hamilton Buchanan in his work *The Fishes of the Ganges* described only those he came across, in his statistical survey of the Bengal Districts, in the Ganges and its tributary streams, except "a few he observed in the rivers of the south of India" (see his Introduction, p. vii); the names of these, however, have no number prefixed to them in the synoptical table. There is no record that Hamilton Buchanan received any collection from the Khasia Hills or Burma. Day, moreover, had adopted for the Bengal fish the name *Barbus stigma*. This name was invented by Cuvier and Valenciennes for a small *Barbus* from Mysore which is a local race of *Barbus sophore* of Hamilton Buchanan, as defined by him in Latin in the synoptical table No. 42 (p. 389) supported by figure 86 of plate xix of his *Illustrations*, as well as by the detailed description in English in which unfortunately two obvious mistakes occur. These mistakes were duly corrected by McClelland and Günther long before Day thought it necessary to take advantage of one of them to change the prior name of a very common species of fish occurring everywhere in ponds in Bengal and to adopt a much later name invented for the local race of the same fish found in Mysore.

The following list gives the distribution of the fish in the lake:—

6	specimens	Barkul ..	.. 13-xi-12,	measuring	19 mm. to 56 mm.
2	,,	,, ..	.. 1-ii-13,	,,	40 mm. and 41 mm.
32	,,	,, ..	.. 21-ix-14,	,,	39 mm. to 51 mm.
2	,,	Off Barkul ..	.. 25-i-14,	,,	40 mm. and 48 mm.
1	specimen	Off Nalbano ..	.. 18-ix-14,	,,	37 mm.
2	specimens	Nalbano ..	.. 25-xi-14,	,,	33 mm. and 42 mm.
1	specimen	Rambha Bay	February, 1914,	,,	43 mm.

The specimens collected during the dry months have the black spots very conspicuous and bright, but do not show any trace of longitudinal coloured bands, nor are their fins tinted pink. On the other hand the specimens collected after the floods are found to have one or other of the two black spots indistinct or wanting, and most of them show coloured longitudinal bands and the ends of the ventral fins are pink. In some, however, no coloured bands are visible—and in these the upper half of the body is dark brown and the lower half dull silvery.

Distribution:—Fresh waters of India and also in tidal rivers from Sind to Burma including Assam.

Barbus ticto (Hamilton Buchanan).

1822. *Cyprinus ticto*, Hamilton Buchanan, *Fish. Gang.*, pp. 314 and 389, pl. viii, fig. 87.
1839. *Systomus ticto*, McClelland, *Asiat. Researches*, XIX, p. 382.
1841. *Rohtee ticto*, Sykes, *Trans. Zool. Soc.*, p. 365.
1849. *Systomus ticto*, Jerdon, *Madr. Journ. Lit. Sc.*, XV, p. 318.
1849. *Systomus tripunctatus*, *id.*, *ibid.*, XV, p. 316.

1878. *Barbus ticto*, Day, *Fish. Ind.*, p. 576, pl. cxliv, fig. 7.
1889. *Barbus ticto*, Day, *Faun. Brit. Ind., Fish.*, I, p. 325.

There are three specimens of this species in the collection obtained from different parts of the main area at different periods of the year as stated below:—

1	specimen	Off Barkul	25-i-14,	measuring	27 mm.
1	,,	Rambha Bay ..	March, 1914,	,,	31 mm.
1	,,	Between Samalkuda and Barkuda	15-xi-14,	,,	19 mm.

In the first two specimens the anterior black blotch is less conspicuous and the third specimen is dark brown all over.

The species is a permanent inhabitant of the main area throughout the year and breeds in it.

Distribution:—Fresh waters of India and Ceylon, extending to brackish waters.

Barbus vittatus, Day.

1865. *Puntius vittatus*, Day, *Proc. Zool. Soc.*, p. 303.
1865. *Puntius vittatus*, Day, *Fish. Malab.*, p. 215, pl. xiii.
1867. *Puntius sophore*, Kner, *Novara Fische*, p. 347.
1878. *Barbus vittatus*, Day, *Fish. Ind.*, p. 582, pl. cxliv, fig. 2.
1889. *Barbus vittatus*, Day, *Faun. Brit. Ind., Fish.*, I, p. 333.

There are three specimens in the collection measuring from 20 mm. to 22 mm.; they were obtained at Satpara on 17-iii-14. In all these specimens the anterior black spot is altogether wanting. The inferior black spot is anterior to the anal fin and is not at its base.

The species appears to be confined to the outer channel. The specimens were collected in the middle of March in water as salt as that of the Bay outside.

Distribution:—Madras, Malabar, Cutch and Ceylon.

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FAUNA OF THE CHILKA LAKE.

FISH.

PART II.

By B. L. Chaudhuri, *D.Sc.* (*Edin.*), *F.R.S.E.*, *F.L.S.*

(With 8 text-figures.)

CONTENTS.

FISH. (*PART II.*)

By B. L. CHAUDHURI.

This part contains a systematic treatment of the suborders Apodes, Haplomi and Catosteomi of the Order Teleostei. The total number of specimens examined and recorded is 245. They belong to only nine species. Of these one (*Ophichthus chilkensis*) is new to science, while one (*Hippocampus brachyrhynchus*) has recently been described in the *Records of the Indian Museum.* The nine species fall into seven genera and five families.

Suborder *APODES.*

Family ANGUILLIDAE.

Genus **MURAENESOX**, M'Clelland.

Muraenesox cinereus (Forskål).

1775. *Muraena* (*Toto*) *cinerea*, Forskål, *Descrip. Anim.*, pp. x, 22.
1801. *Muraena arabica*, Bloch and Schneider, *Syst. Ichthyol.*, p. 488.
1803. *Muraena sp.* [*Taloopaum*], Russel, *Fish. Vizag.*, I, No. 36, p. 25.
1822. *Muraena bagio*, Hamilton Buchanan, *Fish. Gang.*, pp. 24, 364.
1843. *Muraenesox tricuspidata*, M'Clelland, *Cal. Journ. Nat. Hist.*, IV, p. 409, pl. xxiv, fig. 1.
1844. *Congrus tricuspidatus*, Richardson, *Ichthyol. Voy. Sulphur*, p. 105, pl. li, fig. 2.
1845. *Muraenesox hamiltoniae*, M'Clelland, *Cal. Journ. Nat. Hist.*, V, p. 182, pl. viii, fig. 3.
1845. *Muraenesox bengalensis*, M'Clelland, *ibid.*, V, p. 182.
1846. *Conger hamo*, Temminck and Schlegel, *Faun. Jap. Poiss.*, p. 262, pl. cxiv, fig. 2.
1849. *Conger bagio*, Cantor, *Journ. Asiat. Soc. Bengal*, 1849, p. 1298.
1856. *Muraenesox bagio*, Kaup, *Cat. Apod. Fish*, p. 116, pl. xiv, fig. 73.
1870. *Muraenesox cinereus*, Günther, *Brit. Mus. Cat. Fish.*, VIII, p. 45.
1878. *Muraenesox cinereus*, Day, *Fish. Ind.*, p. 662, pl. clxviii, fig. 4.
1889. *Muraenesox cinereus*, Day, *Faun. Brit. Ind. Fish.*, I, p. 91.
1909. *Muraenesox cinereus*, Günther, *Fisch. Sudsee*, III, p. 395.

There is one specimen in the collection. It was obtained in the lake at the end of July, 1913. It measures two feet and nine inches in length. The specimen is of a somewhat "shining golden colour" as described by Russel, though some of the later writers disputed the correctness of his description.

Hamilton Buchanan's specimen was probably a young one—hence his conclusion that the fish grew only to eighteen inches or two feet in length, the difference of colour being probably also due to difference in age. Other slight inaccuracies in his description were due to his not having his original drawings with him at the time of writing. He had left them behind in India along with others. Plate XXIX of the one

hundred and forty-four coloured figures of the manuscript volume of his drawings, now in possession of the Asiatic Society of Bengal, is the original drawing of this species.[1] The name first written on the plate was "*Ophisuroides*." This was afterwards altered by Buchanan in his own handwriting to *Muraenophis bagi*. There is an indifferent reproduction of this plate by M'Clelland in which all the proportions are inaccurate and the apertures of the nostrils are incorrectly copied.

Measurements of the specimen from the Chilka Lake are given below:—

Length of head	135 mm.
Distance from snout to vent..	370 ,,
Distance from vent to end of tail	480 ,,
Length of snout	36 ,,
Length of pectoral fin	45 ,,

The dorsal fin begins 27 mm. in front of the branchial opening.

This fish is probably only a stray visitor to the lake; a curious fact, however, is that in the present instance the specimen was found in water that was almost fresh.

Distribution:—Coasts of Arabia and Africa, and seas and estuaries of India, the Malay Archipelago, Australia, China and Japan.

Family MURAENIDAE.

Genus RHABDURA, Ogilby.

Rhabdura macrura (Bleeker).

1854. *Muraena macrurus*, Bleeker, *Ichth. Bant. Nat. T. Ned. Ind.*, VII, p. 324.
1856. *Thyrsoidea longissima*, Kaup, *Cat. Apod. Fish*, p. 82.
1864 *Thyrsoidea macrurus*, Bleeker, *Atl. Ich.*, IV, p. 111, t. clxvi, f. 2.
1878. *Muraena macrura*, Day, *Fish. Ind.*, p. 672, pl. clxx, fig. 5.
1889. *Muraena macrura*, Day. *Faun. Brit. Ind. Fish.*, I, p. 81, fig. 32.
1907. *Rhabdura macrura*, Ogilby, *Proc. Roy. Soc. Queensland*, XX, p. 13.
1909. *Muraena macrurus*, Günther, *Fisch. Sudsee*, III, p. 421.
1910. *Evenchelys macrurus*, Jordan and Richardson, *Mem. Carneg. Mus.*, IV, p. 175.

There is one specimen in the collection. It was secured near Satpara in the month of March, 1914. The specimen measures nearly four and a half feet in length.

The word "twenty" in Kaup's description, stating that the length of the head is contained twenty times in the length, is probably a mistake for "ten." The species, however, is exceedingly elongate and the tail is more than double the length of the trunk. The colour is uniformly blackish brown. The lateral line runs higher up than the middle line and commences in this specimen about 50 mm. anterior to the gill-slits. It consists of a series of detached elongated dashes on each side. The following measurements of the specimen are of interest:—

[1] This volume of manuscript drawings of Dr. Buchanan (afterwards Hamilton), consisting of 144 coloured figures of fishes executed by Indian painters under his supervision, was deposited in the library of the Royal Botanic Gardens at Sibpur in 1815. It was transferred from there to the library of the Asiatic Society of Bengal by Mr. W. Griffith in 1843. This drawing (plate xxix) of the fish is therefore the earliest figure of the species extant.

Length of head	130 mm.
Distance between end of snout and vent	525 ,,
Distance between vent and end of tail (tail)	850 ,,
Length of snout	13 ,,
Long diameter of the eye	6 ,,
Interorbital space	11 ,,
Length of upper jaw	44 ,,
Length of lower jaw	46 ,,

The fish is a casual visitor to the outer channel of the lake during the period of maximum salinity.

Distribution :—Indian Ocean, seas of India, Ceylon and the Malay Archipelago. Also reported from Natal, Australia and Formosa.

Family OPHICHTHYIDAE.

Genus **OPHICHTHUS,** Ahl.

Ophichthus chilkensis, sp. nov.

(Text-figures 12, 13.)[1]

The length of the head is 17·7 % of the distance between the end of the snout and the vent, the length of the snout is 2·5 %, the diameter of the eye is 1·25 %, the length of the upper jaw is 5·6 %, the length of the lower jaw is 3·3 %, the depth (*i.e.* the height of the body) at the gill openings is 5 %, the length of the pectoral fin is 4·6 %, the girth behind the pectoral fins is 11·4 %, the free portion of the caudal extremity is 2·5 % of the same distance, which is nearly half (*viz.* $\frac{10}{19}$) the length of the tail (*i.e.* the length of the fish behind the vent), and nearly one-third of the total length.

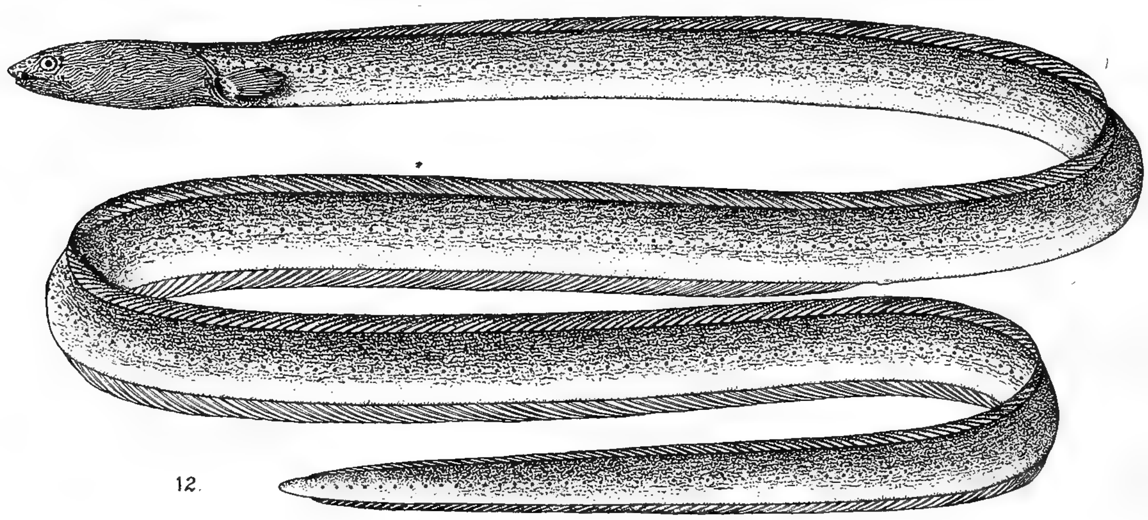
The fish is round, long, and scaleless; the end of the tail projects beyond the dorsal and the anal fins; this free portion is without even a rudiment of a caudal fin. The head is slightly depressed, but the rest of the profile is even.

The length of the head is comparatively small and is contained five and half times in the distance between the end of the snout and the vent. The upper jaw is much the longer, being one and a half times as long as the lower. The anterior tubular nostrils are placed on the upper lip, directed downwards and are thus placed on the inferior side of the end of the snout; the posterior nasal openings, which are patent, are placed right in front of the eyes. The eyes are very small; they are lateral though somewhat superior; the diameter of the eye is contained twice in the length of the snout; the interorbital distance, which is slightly convex, is equal to the length of the snout; the opening of the mouth is horizontal and the angle of the jaws is one diameter of the eye behind the postorbital vertical. The teeth on the vomer are globular and those on the jaw are granular; in the maxilla they are arranged in two rows on each side, the innermost row being serrated; they

[1] The text-figures are numbered in continuation of those that appeared in Part I of the paper.

are in two rows also in the mandible; there are no canine teeth (text-fig. 13). The lips are not fringed. The tongue is fully adnate to the floor of the mouth.

The gill-openings are low down and are oblique slits, wide apart anteriorly; the posterior ends of these slits are somewhat closer; the opercular flaps (*i.e.* margins of the slits) are slightly concave; the length of these slits is equal to the length of the snout. The opercular covering becomes continuous with the loose and the swollen integument over the accessory branchial cavity. The pectoral fin is slightly elongated and fan-shaped and is supported by fourteen branching rays; the length of this fin almost equals that of the upper jaw. The dorsal fin is rather low, though it is higher than the anal fin; it begins behind the opening of the gill-slits at a distance of one-third of the length of the head and continues the whole length of the back, stopping short only at the free end of the caudal extremity, and is thus not continuous with the anal fin. The anal fin is slightly lower than the dorsal fin above and commences close behind the vent at a distance of one diameter of the eye; it continues along the



12.

Fig. 12.—*Ophichthus chilkensis*, Chaudhuri × $\frac{2}{3}$.

mid-ventral line to the free caudal extremity, stopping directly under the end of the dorsal fin above.

The lateral line is well marked throughout the length and appears to be continuous with the system of openings of the muciferous glands on the head; it runs along the side slightly above the middle line.

The colour of the body is dark olive-brown, but it is lighter about the abdomen. The fins are dull white except in the last third of the anal fin, this portion being entirely black.

The generic name *Ophichthus* has priority over *Ophisurus*, which has been used also in other groups. The name *Ophichthys* is of course the more correct form philologically and this corrected spelling was first introduced by Bleeker, who has been followed by recent authors generally. Priority however demands the restoration of the generic name in its original spelling as used by Ahl in 1789.

The new species appears to be intermediate between *Ophichthus boro* (Ham. Buch.)

and *Ophichthus microcephalus* (Day) so far as the length of the head is concerned. The length of the head in the new species is five and a half times in the length from the end of the snout to the vent, whereas in that of *O. boro* it is three and a half to four times and in *O. microcephalus* it is seven and one-third to eight. With respect to the length of the tail the new species approaches *O. microcephalus* rather than *O. boro*.

The new species differs considerably from recently described species of *Ophichthus, viz. O. miyamotonis*, Tanaka,[1] *O. asakusae*, Jordan and Snyder[2]; *O. tsuchidae*, Jordan and Snyder[3]; all from Japanese waters. All of these have much longer heads. The new species in this respect somewhat resembles *O.* (*Bascanichthys*) *hemizona*, Ogilby[4] of the Australian seas (Port Jackson), but differs from it in all other proportions and in colouration. It also greatly differs from *O. frontalis* (Garman)[5] and *O. biserialis* (Garman).[6]

In the shortness of its head the new species resembles *Ophicthus rhytidoderma* (Bleeker), which is the same as the *Pisoodonophis rutidermatoides* referred to by Kaup, but differs from it totally in the character of its teeth and in other particulars.

There are two specimens in the collection, measuring twenty-seven and a half inches (type) and thirty-two and a half inches (co-type) in total length. Both are from Rambha Bay. Some of the important measurements of the two specimens are given below :—

	Rambha Bay. 22-vii-14.	Rambha Bay. 11-iv-14.
Length of head (snout to gill-opening)	42 mm.	66 mm.
Snout to vent	237 ,,	345 ,,
Tail	455 ,,	550 ,,
Diameter of eye	3 ,,	5 ,,
Length of snout	6 ,,	10 ,,
Interorbital distance	6 ,,	10 ,,
Gill-opening to origin of dorsal fin	13 ,,	24 ,,
Free portion of tail	6 ,,	8 ,,

The type-specimen, which was collected on 22nd July, 1914, measures 692 mm. in total length and is entered under No. F $\frac{9177}{1}$ in the register of the Indian Museum. The co-type, which was collected on 11th April, 1914, is 895 mm. in total length. The fish is a permanent inhabitant of the main area of the lake, being obtainable during the period when its water is almost fresh as well as in the period of its maximum salinity. It does not however breed in the lake. In fact none of the eels do so, for no Leptocephalus larvae have been collected during the survey though they are plentiful on the Puri coast.

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[1] Tanaka, *Fishes of Japan*, XI, p. 195.

[2] *Proc. U. S. Nat. Mus.*, XXIII, p. 872, fig. 18.

[3] *Ibid.*, XXIII, p. 873, fig. 19.

[4] *Proc. Linn. Soc. New South Wales*, XXII, p. 248 (1897).

[5] *Mem. Mus. Comp. Zool. Harvard*, XXIV, p. 309.

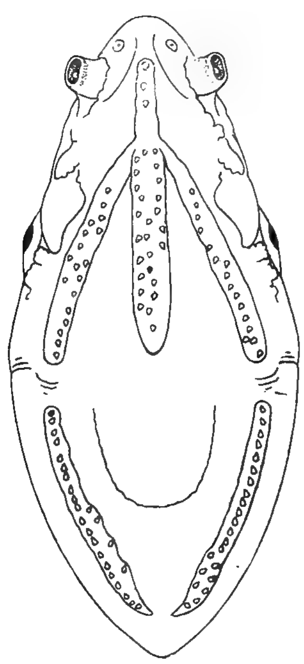
[6] *Ibid.*, XXIV, p. 311.

Ophichthus hijala (Hamilton Buchanan).

(Text-figure 14.)

1822. *Ophisurus hijala*, Hamilton Buchanan, *Fish. Gang.*, pp. 20, 363, pl. v, fig. 5.
1832. *Ophisurus hyala*, Cuvier, *Reg. Anim. Poiss.*, p. 317.
1845. *Ophisurus rostratus*, M'Clelland, *Cal. Jour. Nat. Hist.*, V, pp. 184, 211.
1845. *Ophisurus vermiformis*, M'Clelland, *ibid.*, V, pp. 184, 212, pl. xii, fig. 2.
1845. *Ophisurus minimus*, M'Clelland, *ibid.*, V, pp. 185, 212, pl. x, fig. 3.
1845. *Ophisurus caudatus*, M'Clelland, *ibid.*, V, p. 185, pl. xii, fig. 3.
1845. *Ophisurus hijala*, M'Clelland, *ibid.*, V, p. 211.
1849. *Ophisurus grandoculis*, Cantor, *Jour. Asiat. Soc. Bengal*, 1849, p. 1306, pl. v, fig. 3.
1856. *Pisoodonophis boro* (in part), Kaup, *Cat. Apod. Fish Brit. Mus.*, p. 17.
1870. *Ophichthys hyala*, Günther, *Cat. Fish. Brit. Mus.*, VIII, p. 60.
1878. *Ophichthys boro* (in part), Day, *Fish. Ind.*, 664.
1889. *Ophichthys boro* (in part), Day, *Faun. Brit. Ind. Fish.*, I, p. 95.

There is only one specimen in the collection, secured on the 31st August, 1913, at Balugaon. It is twenty-two inches in length. The round dark grey blotches



13.

FIG. 13.—*Ophichthus chilkensis*, Chaudhuri.
Teeth of upper jaw, palate and lower jaw.

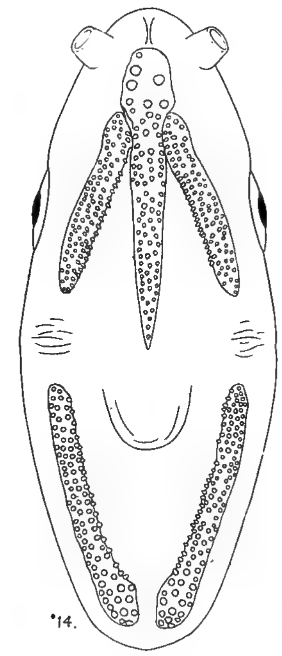


FIG. 14.—*Ophichthus hijala* (Ham. Buch.).
Teeth of upper jaw, palate and lower jaw.

(larger than the eyes) on the anterior portion of the lateral line, which are characteristic markings of the species, are very conspicuous along the lateral lines; they begin a little in front of the gill-opening and continue to the region of the vent, and are twenty-four in number.[1] These markings are not found in *O. boro* (Ham. Buch.) in any stage of development. The position of the eyes is lateral in the specimen, but

[1] Similar ovate or elliptical spots, twenty-six in number, have been noticed in a recently described species belonging to the genus, *i.e. Ophicthus biserialis* (Garman) from Chatham Island, Galapagos. The spots are placed above and along the lateral line. This species, however, differs from *O. hijala* (Ham. Buch.) in almost all other particulars (*Mem. Mus. Comp. Zool. Harvard*, XXVI, p. 311).

they are visible from below and not when looked at from above, not as in *O. boro*, in which the eyes are superior. The teeth in *O. hijala* are pointed and not granular or globular as in *O. boro*. Kaup thought that "*O. hijala* (H. B.) was the young fish with less-developed teeth" (p. 17). The full grown specimen in the collection falsifies this contention. Hamilton Buchanan thought "*O. hijala* did not grow above eighteen inches in length." The present specimen which is longer by four inches than the stated average length cannot therefore be said to be young. Day sunk the specific name *hijala* (which he spells as "*hyala*" after Cuvier) in the synonymy for *O. boro*, though in the body of his description of the fish under *O. boro* he admits the distinctive character of the teeth in *O. hijala* by saying that the "teeth are conical in the young, which character may be retained in the adult age as in *O. hiyala*." It should also be noted that in Hamilton Buchanan's work (*Fishes of the Ganges*) the description of *O. hijala* precedes that of *O. boro* and is supported by a figure in the published plates, whereas *O. boro* follows *O. hijala* and is not supported by any figure. If therefore these two names of Hamilton Buchanan stand for one and the same species, the name *O. boro* should lapse and not *O. hijala*. However, as has been shown above, *O. hijala* is quite a distinct species.

Hamilton Buchanan's published figure of *O. hijala* is however defective (Plate V, fig. 5). The pair of tubular nostrils (the tag-like organs on the snout) are shown to be attached on the superior surface of the snout and are directed upwards in the figure, whereas they are on the underside of the snout, are lateral and inferior and are directed downwards. The eyes are shown to be above the angle of the jaw, whereas they are actually situated about the middle of the opening of the mouth.

There is a figure of this snake-eel in Hamilton Buchanan's manuscript drawings (p. 443 *ante*) on plate No. 27 of the set. The name on the back of the plate in Hamilton Buchanan's own handwriting is *Ophisurus rostrata*. This is the original and perhaps the only source of the name and description of "*Ophisurus rostratus*" of M'Clelland in volume V of the *Calcutta Journal of Natural History*, pp. 184 and 211. Hamilton Buchanan chose to alter his manuscript name "*rostrata*" to "*hijala*" in his published work "*The Fishes of the Ganges*." It is this rejected manuscript name of Hamilton Buchanan that was restored by M'Clelland through mistake. He says "I have not met with this species."

The following measurements of this unique specimen are of interest :—

Length of head	52 mm.
Length of snout	7 ,,
Diameter of eye	5 ,,
Interorbital space	7 ,,
Length of upper jaw	11 ,,
Length of lower jaw	9 ,,
Snout to vent	215 ,,
Tail	350 ,,
Free portion of tail	4 ,,
Distance between gill-openings and the origin of dorsal fin	32 ,,
Length of pectoral fin	12 ,,

This snake-eel is probably a permanent inhabitant of the main area, only going out to the sea to breed.

Distribution:—Estuaries of Bengal and the sea of Penang.

Ophichthus boro (Hamilton Buchanan).

1822. *Ophisurus boro*, Hamilton Buchanan, *Fish. Gang.*, pp. 20, 363.
1822. *Ophisurus harancha*, Hamilton Buchanan, *ibid.*, pp. 21, 363.
1845. *Ophisurus boro*, M'Clelland, *Cal. Jonrn. Nat. Hist.*, V, p. 211, pl. xii, fig. 4.
1845. *Ophisurus caudatus*, M'Clelland, *ibid.*, V, p. 185, pl. xii, fig. 3.
1849. *Ophisurus boro*, Cantor, *Journ. Asiat. Soc. Bengal*, 1849, p. 1304, pl. v, fig. 2.
1856. *Pisoodonophis potamophelus*, Kaup, *Cat. Apod. Fish Brit. Mus.*, p. 20.
1856. *Pisoodonophis boro* (in part), Kaup, *ibid.*, p. 17.
1865. *Pisoodonophis boro*, Day, *Fish. Malabar*, p. 248.
1870. *Ophichthys boro*, Günther, *Cat. Fish. Brit. Mus.*, VIII, p. 77.
1878. *Ophichthys boro* (in part). Day, *Fish. Ind.*, p. 664, pl. clxxi, fig. 2.
1889. *Ophichthys boro* (in part), Day, *Faun. Brit. Ind. Fish.*, I, p. 94, fig. 41.

There are four specimens of different sizes in the collection varying from sixteen inches to twenty-five inches, all from the main area of the lake.

Hamilton Buchanan had three drawings made of the snake-eels of the Bengal estuaries and they are all preserved in the set of his manuscript drawings (plates xxvi to xxviii) which he had to leave behind him in India (p. 443, *ante*). He however was able to publish the figure of *O. hijala* (corresponding to pl. xxvii of the MSS. Drawings). Of the remaining two, *viz. O. boro* and *O. harancha*, reproductions were published in the year 1834 by Gray,[1] but that of *O. hijala* (pl. xxvii of the MSS. Drawings named thereon as *O. rostrata* in ink) was omitted as it had been already published as fig. 5 of pl. v, in the *Fishes of the Ganges*. The published copies of these illustrations were, however, more widely circulated and became better known than the *Fishes of the Ganges*. *O. harancha*, however, is the same as *O. boro*, as was, in a manner, admitted by Hamilton Buchanan,[2] and subsequently also pointed out by Kaup.[3] This was perhaps not fully realized by Gray, who reproduced both the drawings thinking them to be distinct species. In the *Fishes of Malabar*, Day, following Kaup, sunk *O. harancha* in the synonymy of *O. boro*. It is evident from Day's account of *O. boro* in this work that he then believed *O. hijala* to be quite a distinct species. Günther and others also regarded it as such. In the *Fishes of India*, however, Day, again following Kaup, stated that *O. hijala*, *O. boro* and *O. harancha* were all one and the same species. In doing this he erroneously sunk the prior name *O. hijala* for the later name, evidently being misled by Kaup, who mentioned the two names of Hamilton Buchanan in the reverse order—(probably for the sake of euphony), *i.e.* "*Ophisurus boro* et *hijala*, Ham., *Gang. Fish*, pp. 20, 21, 363"—in his note. This reverse order in his note led Kaup also to mistake the later name for the

[1] *Illustrations of Indian Zoology from the collection of Major-General Hardwicke* by J. E. Gray, Vol. I, pl. xcv, figs. 1 and 2.

[2] *The Fishes of the Ganges*, p. 21.

[3] *Catalogue of Apodal Fishes in the collection of the British Museum*, pp. 20, 21.

species. Day evidently followed Kaup when, by so doing, he found that he could use the more popular name—the *O. boro* of Gray and the *P. boro* of his own *Fishes of Malabar*. Thus *O. boro*, as understood by Day after 1865 and by Kaup from 1856, includes also *O. hijala* of Hamilton Buchanan, and *O. boro* of Kaup and Day represents, in part only, *O. boro* of Hamilton Buchanan.

The Chilka collection comprises specimens of *O. boro* of different sizes, none of which show any of the characters believed to be specific in *O. hijala*.

The following list gives the distribution of *O. boro* in the Lake.

1 specimen ..	.. Rambha Bay	.. ——	measuring	400 mm.	in length
1 ,, ..	.. Balugaon	.. 31-viii-13 ..	,,	410 ,,	,,
2 specimens ..	.. Barkul	.. Sept., 1914...	,,	540 ,,	and 610 mm.

The fish appears to be a permanent inhabitant of the lake in the main area, but it does not breed there.

Distribution:—Seas and estuaries of India and the Malay Archipelago, ascending large rivers above tidal reach; also in the river of the Sambas.

Suborder *HAPLOMI*.

Family CYPRINODONTIDAE.

Subfamily APLOCHEILINAE.[1]

Genus **PANCHAX**, Cuvier and Valenciennes.

Panchax panchax (Hamilton Buchanan).

(Text-figures 15, 17.)

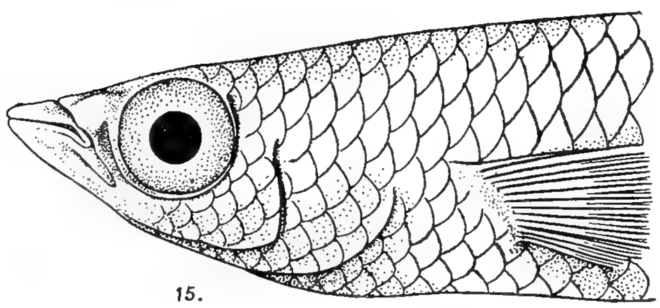
1822. *Esox panchax*, Hamilton Buchanan, *Fish. Gang.*, pp. 211, 380, pl. iii, fig. 69.
1839. *Aplocheilus chrysostigma*, M'Clelland, *Asiat. Research*, XIX, pt. 2, pp. 301, 426, pl. xlii, figs. 2a, 2b.
1839. *Aplocheilus panchax*, M'Clelland, *ibid.*, XIX, pt. 2, p. 302.
1846. *Panchax buchanani*, Cuvier and Valenciennes, *Hist. Nat. Poiss.*, XVIII, p. 383.
1846. *Panchax kuhlie*, Cuvier and Valenciennes, *ibid.*, XVIII, p. 384.
1849. *Panchax panchax*, Cantor, *Journ. Asiat. Soc. Bengal*, 1849, p. 1234.
1853. *Panchax buchanani*, Bleeker, *Nalez. Ichthyol. Beng. Hind.*, p. 144.
1859. *Panchax buchanani*, Blyth, *Journ. Asiat. Soc. Bengal*, XXVII, p. 288 (1858).
1863. *Panchax buchanani*, Bleeker, *Atl. Ich. Ind. Orient. Neerland.*, III, p. 141, tab. cxliv, fig. 3.
1866. *Haplochilus panchax*, Günther, *Cat. Fish. Brit. Mus.*, VI, p. 311.
1873. *Haplochilus panchax*, Day, *Rep. Fr. Fish. Ind. Burma*, p. cclxxvi.
1878. *Haplochilus panchax*, Day, *Fish. Ind.*, p. 523, pl. cxxi, fig. 3.
1889. *Haplochilus panchax*, Day, *Faun. Brit. Ind. Fish.*, I, p. 427.
1895. *Haplochilus panchax*, Garman, *Mem. Mus. Comp. Zool. Harvard*, XIX, p. 124, pl. iii, fig. 7 (teeth).
1912. *Haplochilus panchax*, Sewell and Chaudhuri, *Ind. Fish. Mos. Dest.*, p. 3, fig. 2.

There are altogether sixteen specimens in the collection, all from the main area of the lake. The list given below will show the time and place of their occurrence in the lake.

[1] Bleeker, *Atl. Ichth. Ind. Orient. Neerland.*, III, p. 140.

8 specimens	.. Off Barkul	..	.. 9—13-xi-12	.. measuring 18 mm. to 38 mm.
2 ,,	.. Barkul Point	..	.. 2-iii-14	.. ,, 25 ,, and 34 ,,
2 ,,	.. Off mouth of Barkul Bay	..	.. 18-ix-14	.. ,, 27 ,, ,, 29 ,,
2 ,,	.. Nalbano Island	..	.. 25-xi-14	.. ,, 36 ,, ,, 41 ,,
1 ,,	.. Rambha Bay	..	.. xii-13	.. ,, 25 ,,
1 ,,	.. Rambha	..	.. ii-14	.. ,, 24 ,,

The jaws are subequal, the upper one is slightly longer and protractile (text-fig. 15). The mouth is large and its opening horizontal; the contour of the opening is convex in front and extends beyond the breadth of the upper jaw to nearly half the



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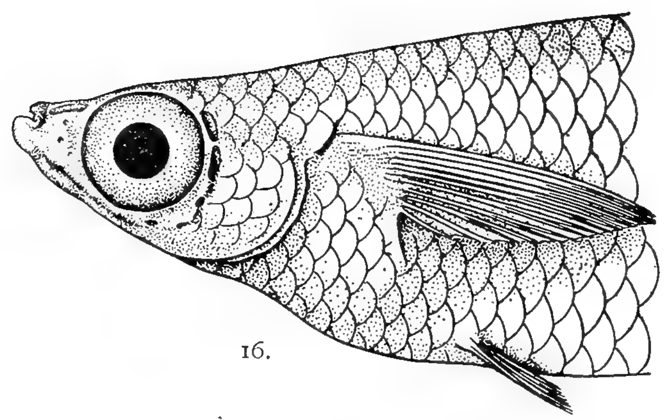


16.

FIG. 15.—*Panchax panchax* (Ham. Buch.).

Side view of the head and a portion of the trunk, showing the lateral and horizontal opening of the mouth and the position of the pectoral fin.

FIG. 16.—*Aplocheilus melastigma*, M'Clell.

Side view of the anterior part of the fish, showing the small and terminal opening of the mouth and the position of the pectoral fin

length of the snout (text-figs. 15 and 17). The teeth in the upper jaw are villiform and are distinctly banded; in the lower jaw they are in two to three rows and also villiform and banded. In both the jaws there are an outer and a more or less distinct inner series of enlarged teeth. In most specimens the vomerine teeth are present. The margin of both the jaws is coloured dark brown. The white occipital spot is very conspicuous in some specimens, in others it is indistinct and in rare cases wanting. The presence or absence of this spot appears to have no reference to age, locality, or time of the year when the specimen was collected. The black blotch at the root of the dorsal fin, which is well marked in all the specimens, is in some surrounded by a white halo. In some of the larger specimens the margin of the anal fin and in

some cases that of the caudal fin is coloured black with a yellow band inside. Most of the specimens have twenty-six scales from the end of the snout to the origin of the dorsal fin, and five scales between the post-orbital line and the origin of the pectoral fin. Generally there are three to four scales from the top of the pectoral fin to the mid-dorsal line of scales, and three scales also between the lower margin of the root of the pectoral fin and the mid-ventral line (text-fig. 15). The ventral fins cover the vent and almost reach the anal papila, which is thin. In adult specimens, collected in November, mature eggs of one millimeter in diameter were found.

The species occurs near the edge everywhere in the main area of the lake, but appears to be entirely absent from the outer channel. It breeds freely in the main area.

Distribution :—Fresh waters (extending to estuaries) in Bengal, Behar, Orissa, Assam, Burma, Siam, the Malay Peninsula and Archipelago and the Andamans. The species has also been reported from Sind, Cutch and the Central Provinces of India.

Genus **APLOCHEILUS** M'Clelland.

Aplocheilus melastigma, M'Clelland.

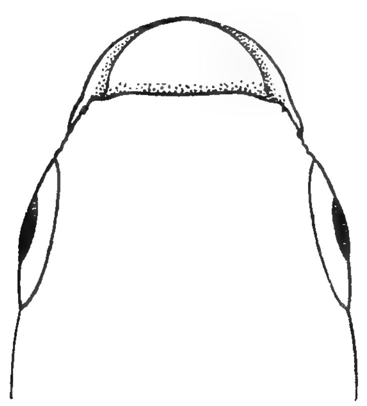
(Text-figures 16, 18.)

1839. *Aplocheilus melastigma*, M'Clelland, *Asiat. Research.*, XIX, pt. 2, pp. 301, 427, pl. xlii, fig. 3.
1839. *Aplocheilus* sp., M'Clelland, *ibid.*, XIX, pt. 2, p. 302, pl. lv, fig. 4.
1846. *Poecilia latipes*, Temminck and Schlegel, *Faun. Japon. Pisc.*, p. 224, pl. cii, fig. 5.
1849. *Aplocheilus carnaticus*, Jerdon, *Madras Journ. Lit. Sc.*, XV, p. 331.
1854. *Aplocheilus macclellandi*, Bleeker, *Nat. Tijd. Ned. Ind.*, VII, p. 323.
1858. *Panchax cyanophthalma*, Blyth, *Journ. Asiat. Soc. Bengal*, XXVII, p. 288.
1860. *Panchax cyanophthalma*, *id.*, *ibid.*, XXIX, p. 111.
1860. *Aplocheilus latipes*, Bleeker, *Act. Soc. Sc. Indo-Neerl.* VII, Japan, VI, p. 99.
1866. *Haplochilus latipes*, Günther, *Cat. Fish. Brit. Mus.*, VI, p. 311.
1866. *Haplochilus cyanophthalmus*, Günther, *ibid.*, VI, p. 312.
1867. *Panchax argenteus*, Day, *Proc. Zool. Soc.*, p. 706.
1873. *Haplochilus argenteus*, *id.*, *Rep. Fr. Fish. Ind. Burma*, p. cclxxvi.
1878. *Haplochilus melastigma*, *id.*, *Fish. Ind.*, p. 522, pl. cxxi, fig. 4.
1889. *Haplochilus melanostigma*, *id.*, *Faun. Brit. Ind. Fish.*, I, p. 415.
1895. *Haplochilus melastigma*, Garman, *Mem. Mus. Comp. Zool. Harvard*, XIX, p. 127.
1895. *Haplochilus latipes*, *id.*, *ibid.*, XIX, p. 128.
1901. *Aplocheilus latipes*, Jordan and Snyder, *Proc. U. S. Nat. Mus.*, XXIII, p. 350.
1907. *Oryzias latipes*, *id.*, *ibid.*, XXXI, p. 289, text-fig. (p. 290).
1912. *Haplochilus melastigma*, Sewell and Chaudhuri, *Ind. Fish. Mos. Dest.*, p. 4.
1913. *Oryzias latipes*, Jordan, Tanaka and Snyder, *Journ. Coll. Sc. Univ. Tokyo*, XXXIII, p. 91, fig. 67.
1913. *Oryzias latipes*, Jordan and Metz, *Mem. Carnegie Mus.*, VI, p. 24, fig. 21.
1916. *Haplochilus melanostigma*, Sundara Raj, *Rec. Ind. Mus.*, XII, p. 293, pl. xxv, figs. 1 and 10.

There are altogether one hundred and eighty-four specimens in the collection. This fish has been found near the edge all over the lake including the outer channel. The following table gives the distribution of the species in the lake.

21 specimens	.. Barkul	..	..9—13-xi-12 ..	measuring from	10 mm.	to 20 mm.
12 ,,	.. Barkul Point	..	.. 2-iii-14 ..	,,	11 ,,	to 22 ,,
2 ,,	.. Balugaon	..	.. 6-iii-14 ..	,,	14 ,,	and 17 ,,
37 ,,	.. Chiriya Island	..	.. 13-ii-14 ..	,,	6 ,,	to 17 ,,
35 ,,	.. Maludaikuda	..	.. 24-xi-14 ..	,,	8 ,,	to 22 ,,
1 specimen	.. Manikpatna (Long Island)		.. 7-ix-14 ..	,,	17 ,,	
27 specimens	.. Nalbano	..	.. 25-xi-14 ..	,,	15 ,,	to 26 mm.
2 ,,	.. Nalbano Channel	..	.. 11-ix-14 ..	,,	17 ,,	and 19 ,,
9 ,,	.. Rambha Bay (Breakfast Island)		xi-14 ..	,,	12 ,,	to 24 ,,
15 ,,	.. Satpara	..	.. ix-13 ..	,,	15 ,,	to 25 ,,
13 ,,	.. Do. ..	..	.. x-13 ..	,,	12 ,,	to 24 ,,

As Blyth observed, this species is less of a surface-fish than *Panchax panchax* (Ham. Buch.). The following peculiarities should be noted. The opening of the mouth is very small, horizontal and transverse, and is not broader than the end



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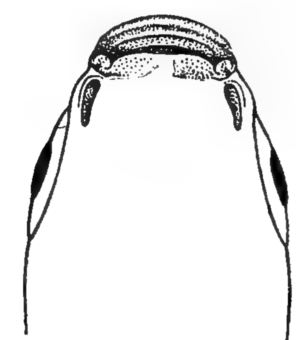


18.

FIG. 17.—*Panchax panchax* (Ham. Buch.).
Anterior part of the head seen from above, showing the form of the snout with premaxillary.

FIG. 18.—*Aplocheilus melastigma*, M'Clell.
Anterior part of the head showing the small and somewhat superior opening of mouth.

of the upper jaw. Its contour is like a much flattened ellipse; the lower jaw, however, is slightly longer and broader and this makes the mouth appear to be somewhat superior and round (text-figs. 17 and 18.) The mouth is not protractile. The teeth are simple and pointed and are in two rows in the jaws, but those in the posterior row are very minute and often difficult to detect. There are no vomerine teeth. The eyes are lateral and their superior borders bulge out slightly on the surface of the head. There are three to four scales between the upper border of the pectoral fin and the mid-dorsal line; there are nearly seven scales between the inferior border of the root of the pectoral and the mid-ventral line (text-fig. 16); the number of scales in front of the dorsal fin is twenty-eight only; there are three scales between the post-orbital line and the root of the pectoral fin. The base of the pectoral fin is very muscular and swollen. The caudal fin is truncated and square-cut. In some specimens there are two black lines about the middle of the anal fin running parallel to its edge, besides the black lines running along the middle of the fish and along the border of the anal fin. In some specimens there are numerous black spots over the

upper corner of the base of the pectoral fin, over parts of the operculum and on the sides of the abdomen. Many of the bigger specimens are full of mature eggs. One specimen collected from the edge of the lake at Satpara in the month of September, measuring twenty-five millimeters in length, had a cluster of about forty eggs with growing embryos inside most of them. This egg-cluster was attached between the ends of the ventral fins and the beginning of the anal fin. There are numerous hooklets round each of the capsules of the eggs, which give them a characteristic appearance somewhat like a miniature model of the fruits of the well-known *Datura*. The anal papila is flat, thick and leaf-like, with a notch in the middle.

As Tate Regan has conclusively shown (*Ann. Mag. Nat. Hist.*, (8), VII, p. 324) the genus *Oryzias* of Jordan and Snyder is a synonym of *Aplocheilus*, M'Clelland, afterwards definitely restricted by Bleeker to the group to which it is now applied. Examination of a large number of *A. melastigma* has led me to suspect that *A. latipes* (Temminck and Schlegel), the type of the genus *Oryzias* of Jordan and Snyder, is in all probability identical with *A. melastigma*. This suspicion has been confirmed by the same species being found among a collection of small fish made by Dr. N. Annandale, in September 1915, in the outskirts of Shanghai. Günther, in a manner, long ago comprehended the identity of these two species. Though he omitted *A. melastigma*, M'Clelland, from his *Catalogue of Fishes in the British Museum* as a doubtful species, he adopted its synonym *H. cyanophthalmus*, Blyth, as a valid one. The collection, on the examination of which he based his identification of Blyth's species, came from Calcutta, but his difficulty was that the fin had nineteen anal rays only as in *A. latipes* and not twenty-two. Though most of the Chilka specimens have twenty-two anal rays, I find that some have eighteen, twenty or twenty-one. In other respects they are almost alike. Recently this Museum has received a valuable collection of representative fish from Lake Biwa, Japan, in excellent condition, from the Rinko Zikkensho of Otsu. In this collection there is one specimen labelled *Oryzias latipes* (Temm. and Schleg.) which appears to us to be a perfectly typical example of *A. melastigma*, M'Clelland. The acquisition of specimens from Lake Biwa and Shanghai has given us an opportunity to institute a close comparison between the Japanese specimen and those from Shanghai and the Chilka Lake. The result of this examination is tabulated below :—

	LAKE BIWA, JAPAN.	SHANGHAI.		CHILKA COLLECTION.		
		A.	B.	Rambha Bay.	Nalbano Island.	Barkul Point.
Number of rays in the anal fin ..	18	20	19	22	18	21
Number of scales along the lateral line ..	31	30	31	30	29	30
Number of scales along the mid-transverse line.	9	9	9	9	9	9
Length of head ..	6 mm.	5 mm.	5 mm.	7 mm.	6 mm.	5 mm.
Depth of body ..	5·5 mm.	4·5 mm.	4·5 mm.	7 mm.	5·5 mm.	4·7 mm.
Number of scales above the pectoral fin ..	4	3	4	4	4	4
Number of scales below the pectoral fin. ..	7	6	7	7	7	7

The proportion between the length of the head and the depth of the fish varies slightly according to sex, as well as in individuals during the breeding season and also owing to other causes; no very great value, therefore, should be attached to slight differences in the depth. Jordan and Snyder appear to have ignored the generic character of *Aplocheilus* (*s. s.*) in instituting their genus and do not allude to the fact that in *A. javanicus*, Bleeker, the anal fin is even longer than in the specimens of the species they examined, having twenty-five rays.

The species occurs all round the edge of the lake including the outer channel. It is a permanent inhabitant and breeds freely in the lake.

Distribution:—Madras, Orissa, Bengal, Burma, the Kiangsú Province of China, Formosa, Korea and Japan.

Suborder *CATOSTEOMI.*

Family SYNGNATHIDAE.

Genus **ICHTHYOCAMPUS**, Kaup.

Ichthyocampus carce (Hamilton Buchanan).

1822. *Syngnathus carce*, Hamilton Buchanan, *Fish Gang.*, pp. 13 and 362.
1832. *Syngnathus carce*, Gray, *Illust. Ind. Zool. Hardwicke*, I, pl. lxxxi, fig. 1.
1853. *Syngnathus carce*, Bleeker, *Nalez. Ichth. Faun. Beng. Hindost.*, p. 161.
1856. *Ichthyocampus carce*, Kaup, *Cat. Lophob. Fish Brit. Mus.*, p. 30.

1856. *Ichthyocampus ponticerianus, id., ibid.*, p. 31.
1865. *Ichthyocampus ponticerianus*, Day, *Fish. Malabar*, p. 263.
1870. *Ichthyocampus carce*, Günther, *Cat. Fish. Brit. Mus.*, VIII, p. 176.
1878. *Ichthyocampus carce*, Day, *Fish. Ind.*, p. 679, pl. clxxiv, fig. 2.
1889. *Ichthyocampus carce*, Day, *Faun. Brit. Ind. Fish.*, II, p. 464.

There are altogether fifteen specimens in the collection, of which nine are males and six females. In all the female fish, on the inferior side of the rostrum, there are two longitudinal series of black dots, one on each side of the middle line and running parallel to it. The following list gives the distribution of the species in the lake.

Female specimens.

1 specimen	Off Barkul	25-1-14	measuring	120 mm.
1 ,,	Domkuda	18-vii-14	,,	100 ,,
3 ,,	Off Samal Island	22-ix-13	,,	100, 110 and 115 mm.
1 ,,	Satpara		,,	100 mm.

Male specimens.

1 specimen	Between Chiriya Island and mainland	28-vii-14	measuring	95 mm. Pouch full of fertilized eggs but no free embryo.
1 ,,	Eight miles off Kalupara Ghat	16-ix-14	,,	95 mm. Pouch empty.
1 ,,	Ten miles east of Patsahanipur	10-iii-14	,,	130 mm. Pouch empty.
2 ,,	Patsahanipur	8-iii-14	,,	40 and 58 mm. Pouch not fully developed.
1 ,,	Rambha Bay	22-vii-14	,,	61 mm. Pouch not fully developed.
1 ,,	Satpara	——	,,	117 mm. Pouch full of developing embryos.
2 ,,	Chilka Lake	——	,,	95 and 120 mm. Pouch full of developing eggs and a few free embryos.

Distribution:—Seas, estuaries and fresh waters of India and the Malay Archipelago.

Genus **HIPPOCAMPUS**, Rafinesque.

Hippocampus brachyrhynchus, Duncker.

(Text-figure 19.)

1914. *Hippocampus brachyrhynchus*, Duncker, *Rec. Ind. Mus.*, X, p. 295.

The number of abdominal truncal rings (annuli) is eleven and that of the caudal rings varies from thirty-three to thirty-seven. The number of rings below the dorsal fin (annuli subdorsalis) is $2(—3)+1$. The number of rays in the dorsal fin varies from seventeen to nineteen and that in the pectoral fin from thirteen to fifteen. The number of rays in the anal fin is four. The number of rings in the region of the brood pouch varies from six to eight.

The rings are provided with blunt spines which are nearly uniform, except on the seventh truncal ring and also on the fourth, the seventh, the eleventh and the fourteenth caudal rings, where they are dorsally a little enlarged. The abdominal crista are prominent, in the males they are provided with a black cutaneous fringe (dewlap). There are no cutaneous appendages, except the simple papillae on the breeding-pouch, which are more closely arranged in the posterior half of the pouch. The coronet is scarcely developed. The rostrum is very short and is half to three-fourths in the post-orbital length of the head and up to one and a half times in the orbital diameter. The colour is uniformly dark; there are light radiating stripes from the eye. Total length up to 70 mm.

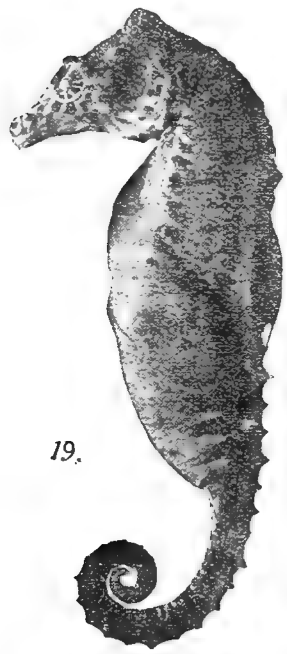

19.

FIG. 19.—*Hippocampus brachyrhynchus*, Duncker, × 2.

Types:—There were altogether nine specimens from Rambha Bay in the series that Dr. George Duncker examined in describing the species, five males and the remaining four females. The type male specimen is registered under No. F $\frac{8508}{1}$ and the type female under No. F $\frac{8539}{1}$ in the register of the Indian Museum.

Besides these nine specimens, there are in the collection twelve more specimens of the species from different parts of the lake, as follows :—

1	specimen	..	♂	..	Domkuda	..	18-vii-14	measuring	45 mm.
1	,,	..	♂	..	Mahosa	..	10-ix-14	,,	38 ,,
1	,,	..	♂	..	Rambha	..	15-ii-14	,,	70 ,,
3	,,	..	♀	..	Rambha	..	15-ii-14	,,	55, 65 and 72 mm.
5	,,	..	(young)		Rambha	..	14-ii-14	,,	10, 12, 16, 18 and 23 mm.
1	,,	..	♀		Seruanaddi	..	8-ix-14	,,	43 mm.

The species is a permanent inhabitant of the lake and breeds in it.

Duncker records it from the Mekran coast (Arabian Sea) as well as the Chilka Lake.

FAUNA OF THE CHILKA LAKE.

SOME TERRESTRIAL ISOPODA FROM THE SHORE OF THE LAKE.

By CHAS. CHILTON, *M.A., M.B., C.M., D.Sc., LL.D., F.L.S., C.M.Z S., Professor of Biology, Canterbury College, University of New Zealand.*

(With 36 text-figures.)

CONTENTS.

SOME TERRESTRIAL ISOPODA FROM THE SHORE OF THE LAKE.

By Chas. Chilton.

INTRODUCTION.

Among the Isopoda and Amphipoda collected during the Chilka Lake Survey, and kindly handed over to me by Dr. Annandale for examination and report, there are four species of Terrestrial Isopoda collected on the shores of the lake. As these are the only representatives of the Oniscoidea[1] in the collection sent to me, and as they differ from the other Isopoda in being terrestrial, it will be convenient to deal with them in a separate report.

Naturally the number of species is small, since the Survey dealt with the lake itself, and only those terrestrial forms found near the shore were collected. Of the four species *Ligia exotica* is the only one that can be looked upon as strictly belonging to the Lake Chilka Fauna. It is a maritime species never found far from the sea-shore. Specimens were obtained during the Survey from two localities near Barkul and from Barkuda Island,[2] where the water is somewhat brackish even during the season when the main area of the lake is filled with fresh water. Most species of *Ligia* live near enough to the sea-shore to be affected by high tides or by the salt spray, but in some cases, where conditions are favourable, they have been found in moist places at some considerable distance from high tide mark. As the margin of Lake Chilka varies considerably during the different seasons and as the salinity of the soil at the southern end is greater than that nearer the mouth of the Mahanaddi, it would probably afford a good opportunity of showing how a maritime species, such as *L. exotica*, may become gradually adapted to more purely terrestrial conditions, but the specimens at present in my hands do not throw any light on this question.

Ligia exotica is a widely distributed species, found on the sea-shore of many parts of the Indian, Atlantic and Pacific Oceans.

The other three species appear to be purely terrestrial forms. The type specimens of *Hemiporcellio carinatus*, previously described by Mr. Collinge (1915, p. 145), were collected "under stones and dead water weeds at the edge of Chilka Lake" at Rambha, and speaking of it Dr. Annandale says, "apparently an amphibious

[1] *Arhina barkulensis*, Collinge (*Rec. Ind. Mus.*, XI, p. 147, pl. viii) was also taken at the edge of the Chilka Lake.

[2] For the position of these places and for information on the geography, hydrography, etc., see the "Introduction" to the "Fauna of the Chilka Lake" by N. Annandale and S. Kemp (1915, pp. 1-20).

species." The specimens sent to me are from Barkuda Island, but without any indication as to whether they were found on the edge of the lake or not. The species, however, is closely allied to *H. hispidus*, Collinge, which is described as a terrestrial species and its occurrence on the shore of the lake is probably only accidental, as several species of the Oniscidae, though really terrestrial, are sometimes found quite close to high water mark on the sea coast.

Hemiporcellio carinatus, Collinge and *Cubaris granulatus*, Collinge, are as yet known only from certain localities near Lake Chilka, though they probably occur in other parts of India. The remaining species, *Alloniscus pigmentatus*, Budde-Lund, if my identification of it is correct, occurs, according to Budde-Lund, also in Madagascar, where it is common, and in many localities in the East Indies.

I have referred the four species to species already described but in each of them, particularly in the case of *Ligia exotica*, I have endeavoured to give information additional to that already published.

I am much indebted to my assistant, Miss E. M. Herriott, M.A., for the care with which she has drawn the figures illustrating the paper.

The references are made by the year of publication to the Bibliographical list on p. 480.

Ligia exotica, Roux.

(Figs. 1 to 22).

Ligia exotica, Roux, 1828, '*Crust. Medit.*', livr. 3, pl. xiii, f. 9.
,, ,, Budde-Lund, 1885, p. 266.
,, ,, Dollfus, 1893A, p. 3 (of separate copy).
,, ,, Dollfus, 1893B, p. 189.
,, ,, Dollfus, 1898, p. 381.
,, ,, Stebbing, 1904, p. 718.
,, ,, Stebbing, 1905, p. 57.
,, ,, Budde-Lund, 1912, p. 391.
Ligia gaudichaudii, Milne-Edwards, 1840, III, p. 157.
,, ,, Nicolet, 1849, p. 265.
,, ,, Dana, 1852, p. 741, pl. xlix, fig. 6 *a-h*.
Ligyda exotica, Richardson, 1905, p. 676.

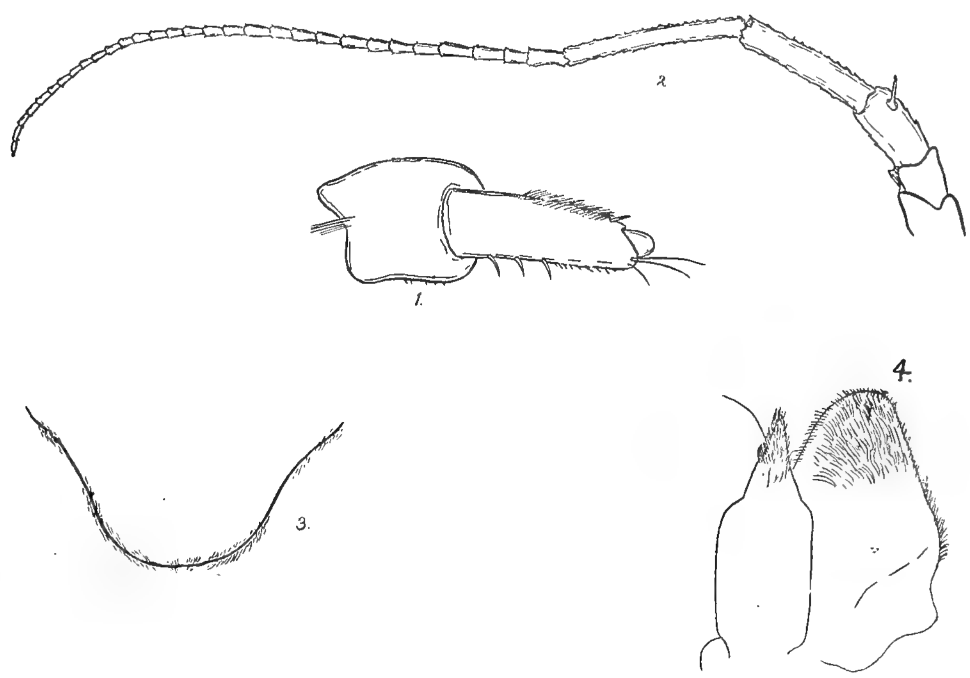
Specimens were obtained from the following localities :—

Barkul, Lake Chilka, Orissa, 9—13-xi-12 (*F. H. Gravely*). Several. Serial Number 7.
Off Barkul, Lake Chilka, Orissa, 21—31-vii-13 (*N. Annandale*). Seven. Serial Number 10, "$\frac{8642}{10}$.'
Barkuda I., under stones just above water level. Feb. 1914. Eleven. Station No. 16, "$\frac{8793}{10}$."

This species is very widely distributed on the warmer shores of the Atlantic, Pacific and Indian Oceans, and it has been recorded on the American coast as far south as Chili and Puntarenas. Though it is so common and has been known for many years, it has received only scanty attention at the hands of those who have recorded it, most observers having merely mentioned its occurrence without adding to previous descriptions. It was briefly described by Milne-Edwards in 1840 under the name of *Ligia gaudichaudii*, and Dana recorded it from various localities under the same name

in 1852. Budde-Lund gave a Latin diagnosis of the species in 1885. In 1893, in his account of the distribution of the genus *Ligia,* Dollfus briefly indicated the characters by which *L. exotica* is distinguished from other species and gave a figure of the posterior portion of the pleon and the uropoda (1893A, p. 3). The only other description that I am acquainted with is that given by Miss Richardson in 1905 in her monograph of the Isopoda of North America. She gives text-figures of the maxillipedes and first peraeopoda and a reproduction of Roux's original figure of the species. She also gives an analytical key to the American species of the genus.

Budde-Lund has called attention to the small process at the end of the propod of the first gnathopod of the male, and Dollfus (1890, p. 7) has referred briefly to the differences between the male and the female in the anterior peraeopoda, but these are



Ligia exotica, Roux.

FIG. 1.—1st antenna of male (highly magnified).
FIG. 2.—2nd antenna of male.
FIG. 3.—Upper lip.
FIG. 4.—Lower lip, seen from posterior side.

the only references I can find to the sexual differences, and the pleopoda do not appear to have been described or figured in either sex. Miss Richardson gives an outline drawing of the maxillipeds, but the other mouth-parts have not been figured nor described in any detail. I have thought it desirable, therefore, to give figures and descriptions of some of the more characteristic parts for comparison with Sars' account of *Ligia oceanica* (1898, p. 156) and with that given by myself of *Ligia novae-zealandiae* (1901, p. 107).

Specific Diagnosis. Body oblong oval, greatest breadth about half the length of body; dorsal surface minutely granular, the granulations becoming smaller and less evident on the segments of the pleon. Antennae about as long as the length of the body. Uropoda when fully developed more than half the length of the body. First

three pairs of legs in male having the merus and carpus dilated; the first pair having a small narrow process at the distal end of the propod. The terminal segment has the middle part of the posterior extremity produced into a subacute point; the postero-lateral angles are long and very acute; the inner angle of the notch for the insertion of the uropod is quadrate and has another quadrate angle near it.

Female differing from the male in having none of the joints of the anterior legs dilated and in the absence of the process on the propod of the first pairs, also in having the side-plates of segments 2, 3 and 4 separated from their segments by a distinct suture.

Length of body of largest male examined, 22 mm.; breadth, 11 mm.; length of antennae 20 mm., length of uropoda 12 mm.

Colour, slaty grey.

In Miss Richardson's key of the American species of the genus *Ligia*, *L. exotica* is placed next to *L. baudiniana*, which is distinguished from it mainly by having the

Ligia exotica, Roux.

FIG. 5.—Right mandible. FIG. 6.—Left mandible.

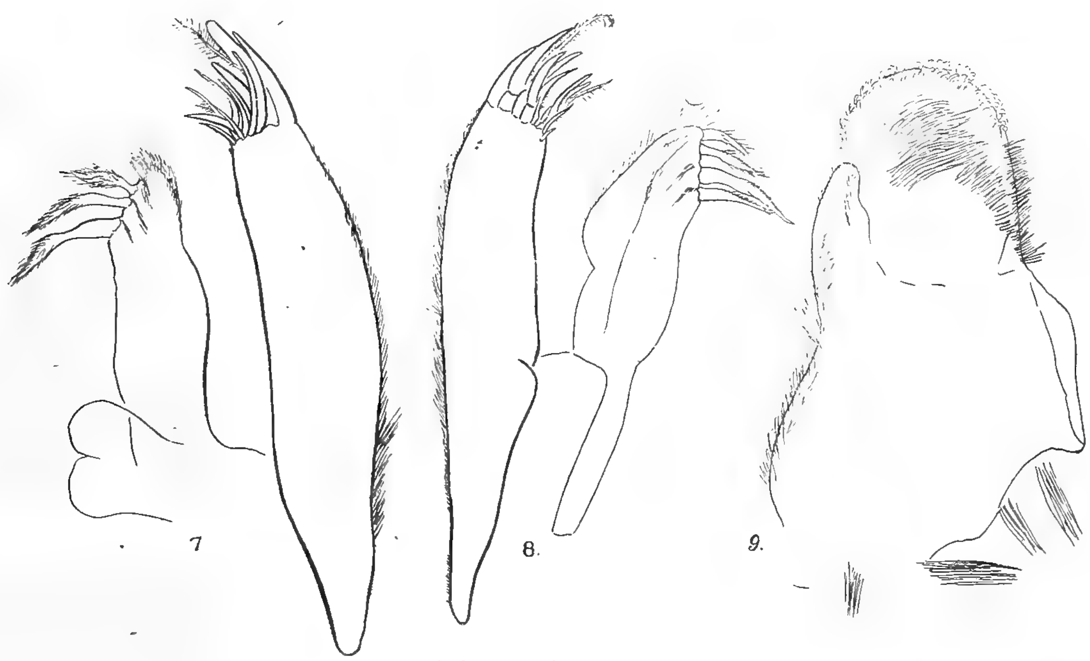
propod of the first pair of legs unarmed, and in having the merus and carpus furnished with a row of stiff hairs or bristles. The two species certainly seem to have many points in common, and, as I afterwards state, it may be difficult to find characters that will distinguish between them in all cases. *L. exotica* also seems to come close to *L. italica*, Fabr., which appears to be distinguished, however, by the shape of the posterior border of the terminal segment. I am not acqainted with any special description of the male of *L. italica*, and the few specimens in my collection are too small and immature to show the characters of the adult male.

In addition to this short diagnosis, the following fuller description of the Lake Chilka specimens may be given.

The head is short and broad; breadth 5 mm. and length 2·5 mm. It is regularly rounded in front and the whole of the lateral margins and a portion of the anterior margin are occupied by the large, rounded eyes which are separated in the centre by a distance less than the length of each eye. The part of the eye nearest to the median line is rectangular with the angle rounded and not acute as in *L. novae-*

zealandiae. On the surface of the head, parallel to the posterior margin, is a narrow furrow, making the posterior margin stand out distinctly, and there is a shallow and less well-marked furrow running outwards and backwards on each side parallel to the posterior margin of the eye. The side-plates of the first segment are completely united with the central portion of the segment, no suture being noticeable; in the 2nd, 3rd and 4th segments *in the female*, there is a distinct suture between the side-plates and the central portion; in the 5th, 6th and 7th, the side-plates are again united with the central portion without a distinct suture. In the male there is no distinct suture even in the 2nd, 3rd and 4th segments, and only an indistinct line or slight groove as in segments 5, 6 and 7.

The question as to whether the side-plates are coalesced with the segments or are separated by a suture is one that is not easy to decide without allowing the



Ligia exotica, Roux.

FIG. 7.—First maxilla of right side, taken from a male specimen with body 22 mm. long.
FIG. 8.—Left maxilla from same specimen showing *four* plumose setae on the inner lobe.
FIG. 9.—Second maxilla.

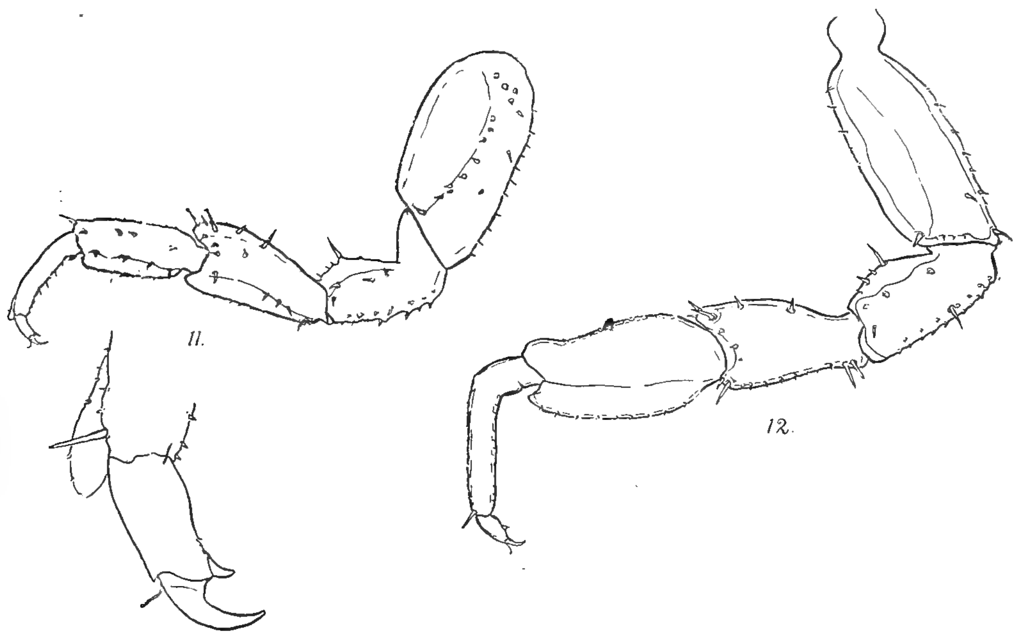
specimens to dry, and this is not always possible. There seems also to be considerable variation in this character in the different species, but there are a few cases which appear to show that the difference between the male and female in this respect holds for more than one genus of the Oniscoidea. For example, I have noted the same thing in *Deto aucklandiae* (1915, p. 438), where the side-plates in segments 2, 3 and 4 are separated from their segments in the female by a suture, while in the males they are quite continuous with the segments. In the other species of *Deto*, however, there appears to be no suture even in the females. Again, in establishing the genus *Anomaloniscus*, Dollfus (1893B, p. 187) gives as one of the chief characters, that there is a suture between the side-plates and the segments in segments 2, 3 and 4 in the female, but not in the male. Apparently it is impossible to lay down a general rule with regard to this sexual difference. Thus, though the difference holds in

the Lake Chilka specimens of *L. exotica* and also in Honolulu specimens of this species in my collection, it does not appear to apply to all the species of the genus; thus, in *L. oceanica*, according to Sars (1898, p. 156), the side-plates are defined "from the corresponding segments by a slight groove." This is certainly the case in the specimens of this species that I have been able to examine, but unfortunately there is no ovigerous female among them, though I presume Sars' description applies to both sexes. In speaking of *L. exotica*, Miss Richardson (1905, p. 677) says, the epimera are "not distinctly separated off from the dorsal portion of the segment, only a faint line, almost inconspicuous, indicates the place where the coalescence has taken place"; she makes no mention of sexual differences in this point, though, as I have said, in ovigerous females from Lake Chilka and from Honolulu, there is a distinct suture in segments 2, 3 and 4. For *L. baudiniana*, Miss Richardson (1905, p. 679) says, "the epimera are coalesced with the segments, faint depressed lines indicating the place of the union"; and she gives a similar description for *L. occidentalis* (p. 682), while in *L. pallasii*, she says, "the epimera of all the segments are broad plates, occupying the whole of the lateral margins of the segments and indicated by distinct lines" (p. 683), though in *L. olfersii* "there is not even any trace, such as a faint line to mark the place where coalescence has taken place" (p. 675). In *L. novae-zealandiae*, Dana, the side-plates in the male are all united with their segments, the union being indicated at most by a faint line; in the female the side-plates of segments 2, 3 and 4 are separated from the segments by a fairly distinct suture and, in most cases, there is on segment 5 a distinct groove corresponding to the suture in the preceding segment. There seems to be also the same want of uniformity in this character in *Deto*: for, while in *D. aucklandiae* there is the same difference between the sexes as in *Ligia exotica*, in the other species of *Deto*, the side-plates are continuous with the segments, and the junction of the epimera is not marked by a distinct groove or suture. In this connection it should be remarked that Dollfus (1893C, p. 343) established the genus *Geoligia*, chiefly on the character that all the side-plates were continuous with their segments. Although it is evident that this character in itself is not sufficient to distinguish the genus *Geoligia* from *Ligia*, the only species of that genus at present known are truly terrestrial, living far away from the sea, and in *Geoligia perkinsii*, Dollfus (1900, p. 525), the uropoda have the branches articulated into several joints instead of being undivided as in *Ligia*.

FIG. 10.—*Ligia exotica*, maxilliped, seen from inner or anterior side.

The whole dorsal surface of the segments of the peraeon is covered with numerous small granulations, some of which seem to be almost acute posteriorly; they are scattered irregularly over the segments without forming any definite rows. In the

1st—5th segments there is a slight furrow just in front of the posterior margin. In the pleon the granulations are smaller and less evident. The posterior border of the first segment is transverse, not being produced backwards at the postero-lateral angle. In the succeeding segments this angle of the side-plate is produced more and more backwards until in the seventh segment it forms an acute point reaching as far back as, or further than, the posterior border of the third segment of the pleon; the first and second segments of the pleon are short and without side-plates; the third, fourth and fifth have well-developed side-plates produced back into acute points, that of the fifth reaching about half way to the end of the terminal segment. The terminal segment is much broader than long, its lateral margins end acutely posteriorly and the posterior border is produced at the centre into an acute point as already described (fig. 20, p. 472).



Ligia exotica, Roux.

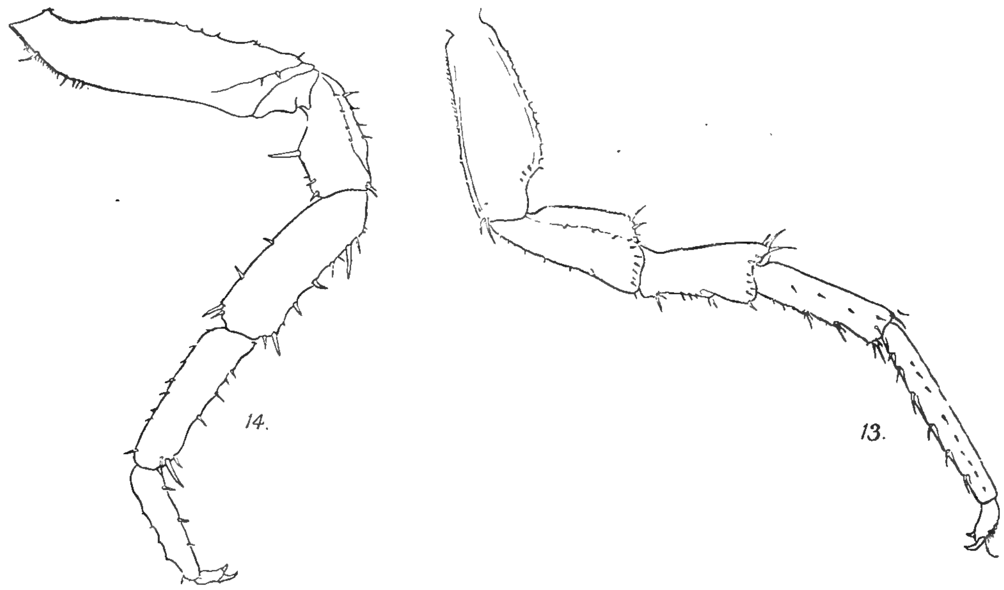
FIG. 11.—First leg of male, with terminal portion more highly magnified.
FIG. 12.—Second leg of male.

Antenna 1 (fig. 1, p. 463) is very small, as usual for this genus and is not visible in a dorsal view of the head; the first joint is nearly as broad as long, and about two-thirds the length of the second, and its margins are almost free from setae; the second is nearly three times as long as broad and is thickly covered on the distal portion with short fine setae, some of them almost scale-like, and there are a few longer setae at the extremity and on the lower margin; the third joint is very short, almost minute, and rounded at the end.

Antenna 2 (fig. 2, p. 463) is, in most cases, fully as long as the body, though the length varies with the development of the animal; the first two joints of the peduncle are short, and slightly grooved on the outer side to receive the third joint when reflexed; the third joint is about as long as the first and second together and bears near the inner distal angle a single, stout seta and is also grooved on the outer side towards the distal end; the fourth joint is about twice as long as the third, but shorter than

the fifth; both bear a few short setules; the flagellum is long and slender, containing about 30 joints and being rather longer than the peduncle.[1]

The second antenna in the male appears to be quite as slender as in the female, instead of being stouter, as in *Ligia oceanica*.



Ligia exotica, Roux.
FIG. 13.—Seventh leg of male.
FIG. 14.—First leg of female.

Mouth-parts. The *upper lip* (fig. 3, p. 463) is large and broad, covering in the anterior portion of the mouth and in the living animal projecting downwards and

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[1] After this was in type I received Dr. H. J. Hansen's report on the Ingolf Isopoda ("The Danish Ingolf Expedition, Vol. III, 5. Crustacea Malacostraca. III"), in which he states (p. 201) that the peduncle of the antenna of *Ligia oceanica* is 6-jointed, though it has usually been described as 5-jointed. He says:

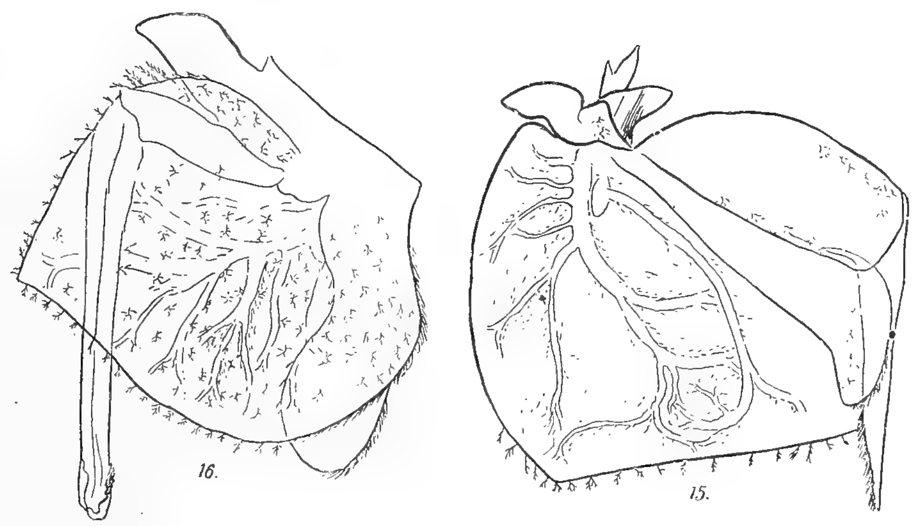
"When the head is inspected from above and somewhat from in front, and the antenna is bent downwards and turned in various directions, we find (fig. 10a) a transverse, movable piece of hard chitine (1) between the head and the major outer part of next joint (2); that transverse piece is the easily seen rudiment of first joint, and the remainder of the peduncle contains five joints. Furthermore a squama (*ex*) is observed on the outer side of third joint; this squama is somewhat broader than long, with its distal half subtriangular and freely protruding, while the proximal half has a semicircular outline and is anchylosed to the joint; it may be added that this suture between exopod and joint is very distinct, but in a very large specimen its median part is obscure."

In consequence of these statements I have re-examined the antennae of *L. exotica*, Roux and also of *L. oceanica*, Linné. I find little real difference between the two species in the points mentioned. In both there is the small movable piece of chitin between the head and the segment of the antenna which is usually looked upon as the first joint; this is very small and I am doubtful if the evidence that it is to be looked upon as a joint homologous to the succeeding one is convincing; neither do I feel sure about the squama on the third joint; the outer margin of this joint is slightly produced in the distal half in *L. exotica*, about as much as in *L. oceanica*, but as far as I can make out this portion is anchylosed to the rest of the segment, and I have previously looked upon it as a small projection forming a notch or groove into which the fourth joint is received when bent back upon the third, as described in the text above for the second joint.

forwards ; its free margin is regularly rounded and fringed in the usual way with short, furry setae, mainly directed towards the median line.

The *left mandible* (fig. 6, p. 464) is large and strong, with a powerfully developed molar tubercle ; the cutting-edge is coloured dark brown or almost black and consists of about 3 or 4 stout teeth ; the secondary cutting-edge in the left mandible shows a structure similar to that of the outer cutting-edge and consists of 4 stout teeth. Between this and the molar tubercle lies the spine-row of about 15 plumose setae, those nearer the molar tubercle becoming progressively longer than the others ; the molar tubercle which projects inwards somewhat obliquely from the body of the mandible is very broad and is thickly covered at its distal end with fine, short setae.

The *right mandible* (fig. 5, p. 464) is similar to the left, except that the inner cutting-edge is quite different in appearance from the outer cutting-edge, being much more



Ligia exotica, Roux.

FIG. 15.—First pleopod of male with male appendage, seen from the posterior side.
FIG. 16.—Second pleopod of male, seen from the anterior side.

delicate in structure and not coloured brown, and consisting of about 8 or 9 small and very acute teeth.

The *lower lip* (fig. 4, p. 463) shows the usual right and left lobes ; they are irregularly rounded and thickly fringed with simple setae which also extend along the outer margin. On the posterior side there is a narrow median lobe projecting at right angles to the rest of the lip and in the natural position of the mouth-parts lying between the maxillae.

The *first maxilla* (fig. 7, p. 465) consists of the usual two lobes, the outer one being narrow oblong, about five times as long as broad ; its outer margin is slightly convex and bears a fringe of fine setae throughout its whole length ; the extremity is tipped with about 10 long spines, the outer ones being larger and darker than the inner, some of them being dark brown or almost black ; the inner ones are finely serrate along the inner margin. In addition to these spines, there is a long, delicate, plumose seta, longer than any of the spines. The inner lobe is delicate and membranous, and on its outer margin it is produced into a thin flange, the more distal portions of which bear a thick fringe of setae ; on the inner distal margin it bears three

large, plumose setae which increase in length proximally. In one specimen examined, a large male, there were 4 setae on the inner portion of the inner lobe of the left maxilla (see fig. 8, p. 465), while the right maxilla bore only the usual three plumose setae.

The presence of three plumose setae or bristles on the inner lobe of the first maxilla is so constant in the Ligiidae and Trichoniscidae, and the presence of only two is such a constant character of the Oniscidae and other families, that the presence of four on the one side of this specimen deserves more than a passing notice. Mr. Collinge's recent paper (1914) shows, however, that there is very considerable variation in the oral appendages of many of the terrestrial Isopoda.

The *second maxilla* (fig. 9, p. 465) is soft and membranous, broad and somewhat thick; its outer margin is sinuous and fringed with simple setae; there is a small outer lobe, much narrower and shorter than the inner lobe; the inner lobe is broadly rounded at the extremity, and has the whole of the distal margin thickly covered with short, curved setae, pointing inwards; on the surface of the inner lobe are many longer, simple setae. In *L. oceanica*, on the inner side of the second maxilla, there are two hairy bristles which are mentioned and figured by Sars (1898, p. 155), who includes them in the characters of the family Ligiidae. These bristles, which are also mentioned and figured by Hewitt (1907, p. 9), are certainly present in the specimens of *L. oceanica* that I have examined, but I can find no trace of them in *L. exotica*, and, as I pointed out in 1901 (p. 106), they are not present in *L. novae-zealandiae.*

The *maxillipeds* (fig. 10, p. 466) close in the mouth cavity behind and have the outer surface fairly smooth or even, while the inner margin is produced at right angles inwards, so as to lie between the bases of the maxillae and come nearly in contact with the median lobe of the lower lip. The epipod is of small size and is fairly well marked off from the rest of the maxilliped and is almost circular, with its margin fringed with fine setae; the palp is about half as long as the basal portion and is not clearly divided into separate joints; the inner lobe is stout and thick and closely fringed at its extremity with numerous short stout spines, the inner margin bearing numerous fine setae.

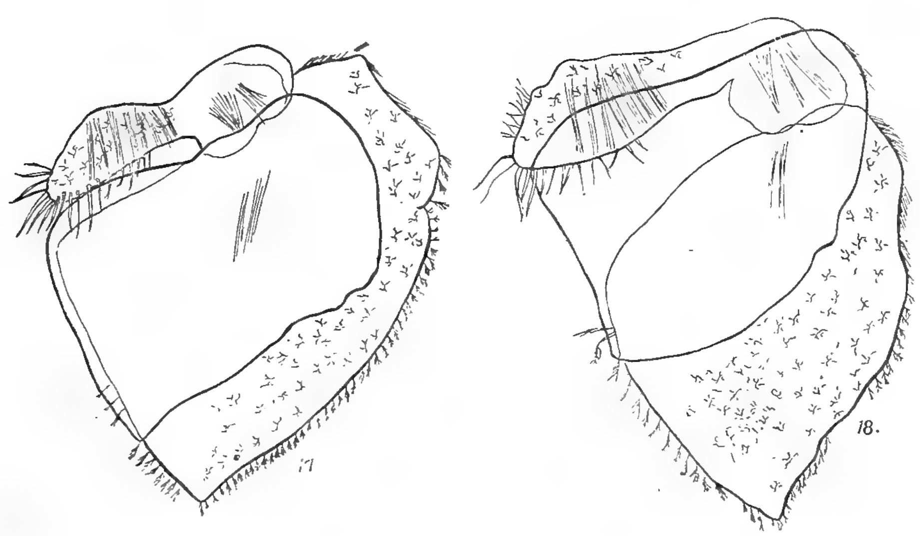
The legs show the usual characters, the anterior ones being somewhat shorter than the posterior, the seventh being the longest In the male the first three pairs are slightly modified and broadened, the propod and dactyl folding back upon the carpus, so as to form an imperfect subchelate appendage. The general shape and arrangement of the various joints can be readily seen from the figures.

In the male, in the first pair (fig. 11, p. 467) the merus and carpus are both somewhat widened and are of about equal length; the inner margin bears only a few rather small setae; the propod is not quite as long as the carpus, and is much more slender; at the extremity it is produced slightly beyond the base of the finger into the small oval lobe characteristic of the species. The dactylar seta is small, short, shorter than the terminal nail and is slightly thickened at the extremity, being on the whole very similar to the corresponding seta of *L. novae-zealandiae.* The second leg (fig. 12, p. 467) is slightly longer and stouter than the first and has the carpus longer and stouter than the merus; the propod is similar to that in the first, but is not produced into a

lobe at the end. The third leg is similar to the second. The remaining legs increase slightly in length up to the seventh (fig. 13, p. 468), and in all of them the merus and carpus are slender, not expanded, and of the usual form, the propod in each is considerably longer than the carpus.

In the female, the legs have the same general shape, but the anterior pairs show no broadening of the merus or carpus, and the propod of the first pair (fig. 14, p. 468) is unarmed. They have the same structure as that seen in the posterior legs of the male, except that in the anterior pairs in the female the propod is slightly shorter than the carpus.

The *pleopoda* on the whole resemble those of *L. oceanica* as described and figured by Professor Sars (1898) and myself (1899). In the first pleopod of the male (fig. 15, p. 469) the outer branch is very large, almost completely covering the inner branch and the male appendage; its inner margin is not produced so much as in *L. oceanica* and



Ligia exotica, Roux.

FIG. 17.—Third pleopod of male, seen from posterior side.
FIG. 18.—Fourth pleopod of male.

the outer angle is rather more rectangular. Its surface shows a branching structure, presumably of blood vessels. The endopod is short and is produced at the inner distal angle. The male appendage is slender, reaching slightly beyond the distal border of the exopod and narrows throughout its length to a rather acute point.

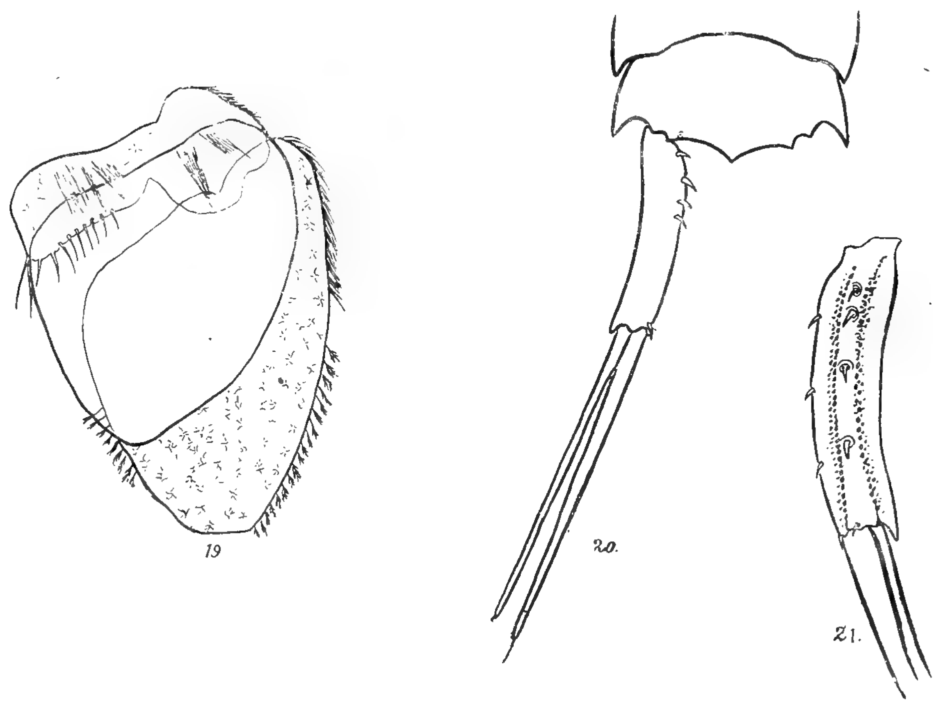
The second pleopod (fig. 16, p. 469) in the male has the exopod similar to that of the first, but with its inner distal angle rather more rectangular. The endopod is modified into a 2-jointed male organ, the first joint much the shorter and lying transversely, the second more than twice as long and extending considerably beyond the exopod; it is grooved throughout its length and ends with a slight irregular enlargement, portions of which are covered with thickly set, short setae, giving a roughened surface like that of a file.

The third, fourth and fifth pleopods (figs. 17, 18, 19) are similar to one another, but the third and fourth are slightly larger than the fifth; in all the exopod is much larger than the endopod and, as in the first and second, has its margins fringed with

fine plumose setae. The endopod is completely branchial in structure and has the margins free from setae. The shape and relative proportions of the different parts of these pleopods will be best learnt from the figures.

In the female the first and second pleopods are on the whole similar to the third, but with the endopods smaller. They are closely similar to those of *L. oceanica* and call for no special description.

The *uropods* (figs. 20 and 21) in the adult are nearly two-thirds the length of the body; the basal joint is nearly straight but with a slight curve outwards; it is triangular in section, the upper surface being flat and the under surface somewhat keeled, both the inner and lower margins bear 3 or 4 short setules in slight serrations, the last one being situated at the extremity, but the number and position of these



Ligia exotica, Roux.

FIG. 19.—Fifth pleopod of male.

FIG. 20.—Terminal segment with uropod, seen from above.

FIG. 21.—Under surface of peduncle of uropod from another specimen.

setules seem to vary considerably in different specimens; the outer margin is thin and bears no setules but is produced into an acute tooth at the distal end. The two branches are long, slender, tapering, subequal in length and considerably longer than the basal joint; the inner one bears at the extremity a long seta, about one-eighth of the length of the inner branch itself, but longer in proportion in very young specimens.

The length of the uropods varies to a considerable extent with the development of the animal, but in the Lake Chilka specimens does not appear to be ever very much greater than half the length of the body. These appendages are, however, so easily detached from the body that it is difficult to get many specimens for which precise measurements can be given. In some of the Honolulu specimens of the species the uropods are rather longer, being fully two-thirds the length of the body;

this is the proportion given by Miss Richardson who makes use of this character in her analytical key of the species of the genus.

The young taken from the incubatory pouch (fig. 22) of the female is 3 mm. long and 1·5 mm. broad. The eyes occupy the whole lateral side of the head and are larger in proportion to the body than in the adult. The seventh segment of the peraeon is short and only partially developed and bears no appendages. The first antennae are larger in proportion than in the adult and can be seen projecting slightly beyond the anterior margin of the head, while the second antennae are short, being less than half the length of the body. The uropoda are also less than half as long as the body, being only about one-third, and have the two branches equal in length, the inner one bearing a long seta at the extremity, nearly half as long as the inner branch itself. The posterior margin of the terminal segment is regularly rounded and not produced into a point in the middle as in the adult.

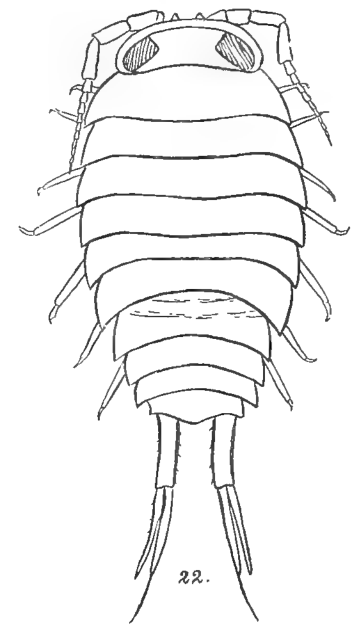


FIG. 22.—*Ligia exotica*, dorsal view of young taken from incubatory pouch of female.

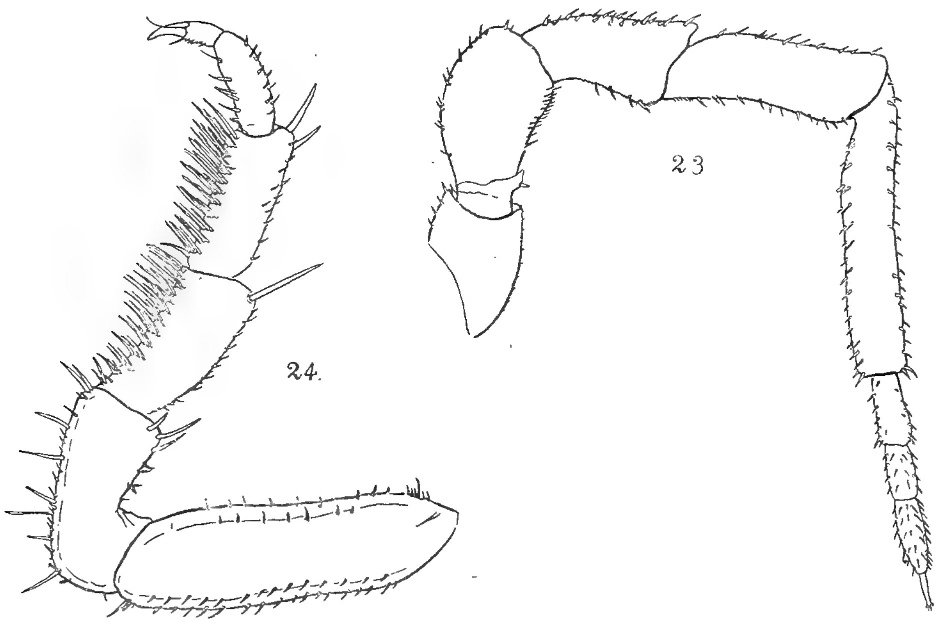
I have been able to compare the Lake Chilka specimens with specimens from Honolulu, Hawaiian Islands, sent to me some years ago by the late G. W. Kirkaldy. These Honolulu specimens agree in all the points given in the short specific diagnosis above with those from Lake Chilka, and must undoubtedly be referred to *L. exotica*, which had already been recorded from Honolulu by Miss Richardson (1905, p. 676); they differ, however, slightly in that the inner margins of the carpus and merus of the first, second and third legs of the male bear more numerous setae than in the Lake Chilka specimens. Some of the specimens also are slightly more slender and have the antennae a little shorter in proportion to the length of the body, though in others the uropoda are longer in proportion and more slender.

In some of these points the Honolulu specimens appear to approach *L. baudiniana*, Milne-Edwards, a species common on the eastern coasts of America as far south as Rio de Janeiro, and at the Bermudas, Bahamas, etc.; and it is possible that when full series of both species are examined, it may be difficult to find characters separating them in all cases. In *L. baudiniana*, however, the propod of the first leg in the male has no process at its distal end. This is present in some of my Honolulu specimens of *L. exotica*, though in some of the younger males it is small and hardly distinguishable. Probably, however, it is only developed to a full extent in fully mature males. In *L. baudiniana*, it seems to be replaced, as it were, in fully developed males by the distinctly marked row of setules on the inner margin of the carpus of the first leg.

In 1890 in his account of the terrestrial Isopoda collected by the 'Challenger,'

Dollfus referred specimens from the Bermuda Islands to *Ligia exotica*, Roux, but distinguished them as a variety *hirtitarsis*, owing to the series of bristles on the carpus of the anterior legs of the male. These specimens, however, would no doubt more properly be referred to *Ligia baudiniana*, with which Miss Richardson has united them.

Collectors' Note. "This species is found in boats and on the shore, where there are stones or rocks, all over the lake. On Barkuda I. it is enormously abundant. Though individuals may be found running on the shore at all times of the day and night, even on rocks heated by the midday sun, the species is most active in the morning and evening. It may then be seen in great droves, numbering sometimes hundreds of individuals, all of which move in the same direction. It is also found on tree-trunks at some little distance from water, but never in dense jungle. When a drove, in its peregrinations by the margin of the lake, comes to a pool of water



Alloniscus pigmentatus, Budde-Lund.
FIG. 23.—Second antenna. FIG. 24.—First leg of male.

the animals do not hesitate to swim across it, but otherwise they avoid water, whether fresh or brackish. In the heat of the day large numbers take shelter under the masses of dead weed that are thrown up on the beach and beneath large stones."

Alloniscus pigmentatus, Budde-Lund.

(Figs. 23 to 28).

Alloniscus pigmentatus, Budde-Lund, 1885, p. 227.
,, ,, Budde-Lund, 1908, p. 297, pl. xv, figs. 23-38.
,, ,, Budde-Lund, 1912, p. 385, pl. xxii, fig. 7.

Barkul Point, Lake Chilka Survey, Station No. 47. No. $\frac{8790}{10}$. About 20 specimens.[1]

[1] I have no information as to the circumstances under which these specimens were collected, but in the tube in which they were sent were several small specimens of an *Aega* or allied genus very similar in colour, size and general appearance to the *Alloniscus pigmentatus*.

Although I have not been able to consult Budde-Lund's paper published in 1908 in which he gives figures of this species, I feel little doubt that the Lake Chilka specimens belong to it. According to Budde-Lund, the species is very common in Madagascar, and is also found in many localities in the East Indies.

In general appearance, the specimens agree well with the short description given by Budde-Lund in 1885. In most respects too, it evidently comes very near to Dollfus's *Anomaloniscus ovatus*, a species which Budde-Lund considers to be identical with *Alloniscus pallidulus*, Budde-Lund. In establishing his genus, Dollfus called attention to the fact that in the second, third and fourth segments of the body, *in the female*, the side-plates were separated from the central portion of the segments by a well-marked suture which was not observable in the males. In the Lake Chilka specimens, even in females, there is no definite suture, only a somewhat indistinct line on the second and third segments. The lateral processes of the head appear much smaller and narrower than those represented by Dollfus for his species, and

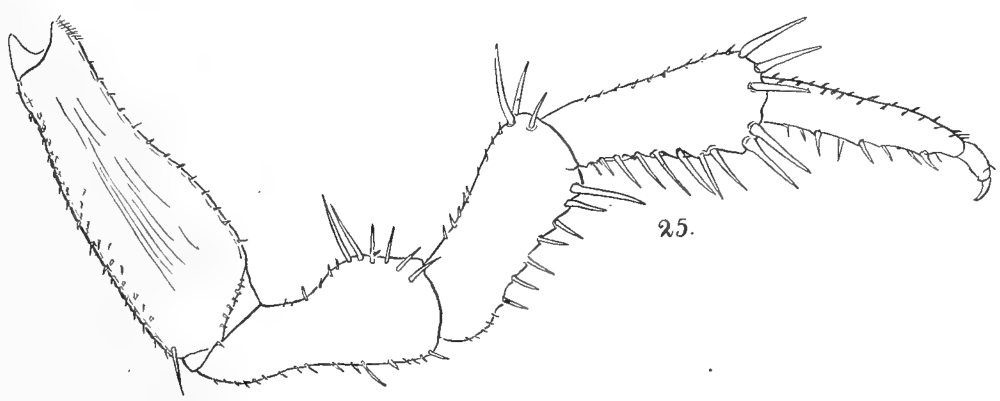


FIG. 25.—*Alloniscus pigmentatus*, seventh leg of male.

for these two reasons I refer the specimens to *A. pigmentatus* rather than to *A. pallidulus*, although the two species seem pretty closely allied

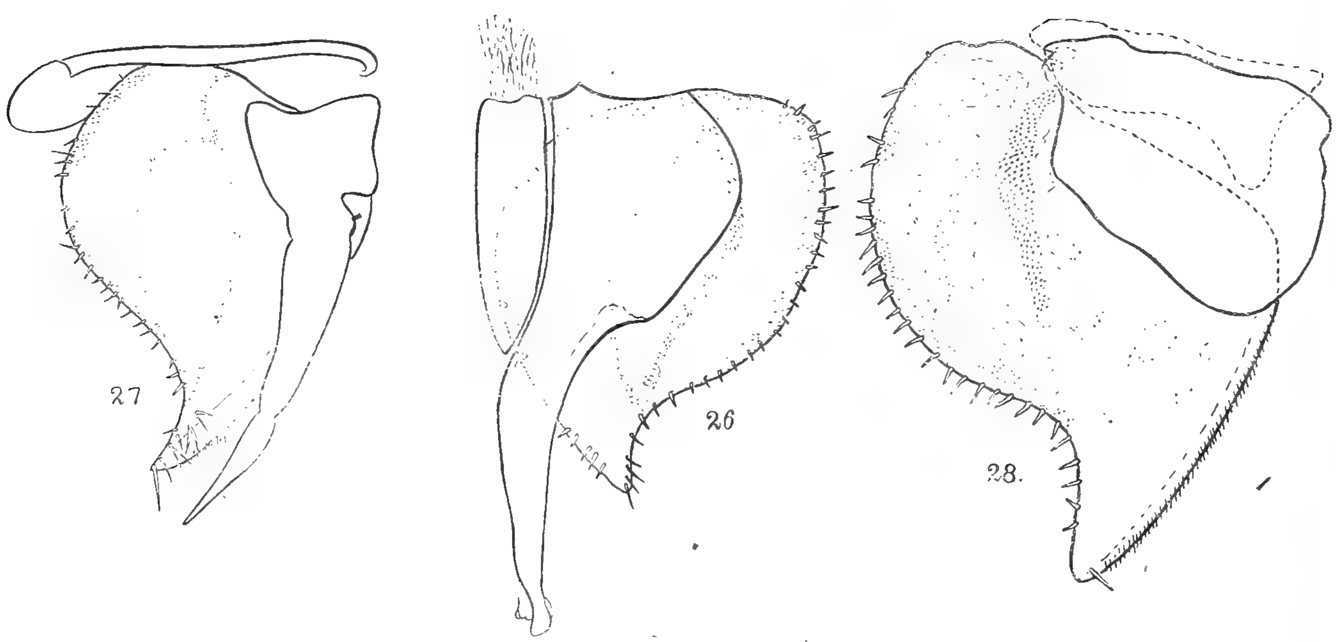
Under the circumstances it is not necessary to give a full description of the Lake Chilka specimens, but as I have been able to examine male specimens, I give figures of the parts of the male that differ from the female and of some of the other appendages.

The second antennae which are the same in both sexes are shown in figure 23; the flagellum is rather shorter than the fifth joint of the peduncle, and has the three joints subequal. In the mouth-parts, the first maxilla corresponds closely with the figure given by Budde-Lund for this species in 1912 (pl. xxii, fig. 7), although I am not clear what he means by saying that the exterior lobe "bears a little appendix not before observed." The exterior lobe appears to present the usual characters, and several of the inner spines of those at its extremity bear a small tooth near the apex, as shown in Budde-Lund's figure; this, however, is a character probably common to other species of the group.

The first thoracic leg in the male (fig. 24) is somewhat long and slender and has the merus and carpus subequal and considerably longer than the propod; both merus

and carpus have the inner margins thickly fringed with tufts or short transverse rows of spinules, as in the case of many other species. The second and third pairs are similar to the first and have the inner margin of the merus and carpus almost or quite as thickly fringed with spinules. The remaining legs increase slightly in length posteriorly, the seventh (fig. 25) being the longest; in all of them there are several large spinules at the outer distal angle of the ischium, merus and carpus, and others on the inner margins especially of the merus and carpus, but these are comparatively few, and well separated, instead of being densely crowded together as in the first three pairs of legs.

In the female the thoracic legs bear only a small number of setae on the various joints as described for the seventh leg of the male. In the first pair the basal joint



Alloniscus pigmentatus, Budde-Lund.

FIG. 26.—First pleopod of male.
FIG. 27.—Second pleopod of male.
FIG. 28.—Third pleopod of male.

is rather long, narrowed at its base, and on the outer side shows clearly the flattened surface or groove which is present on all the legs of this and of many other species.

In the first pleopod of the male (fig. 26) the exopod is large, subtriangular, with its outer margin at first convex and then concave near the subacute apex. The whole of this outer margin and a portion of the inner margin near the apex are fringed with a regular row of rather stout spinules, and the exopod appears to be thickened along this margin and also along two other lines nearer the centre as shown in the figure; this thickening also extends along the basal portion of the inner margin. The endopod is enlarged at the base, having its outer margin very convex, and then narrows somewhat abruptly and curves inwards, gradually narrowing towards the irregularly-shaped extremity; it is strongly chitinised throughout. The male organ proper is single, about half as long as the exopod and narrows regularly with

slightly convex sides to the subacute apex. The second pleopod of the male (fig. 27) has the exopod similar to that of the first, but with the apex rather more acute and with a fringe of fine setae on the inner margin near the apex in addition to the spinules; the endopod has a fairly broad base and narrows abruptly at about one-fourth its length from the base, and then tapers gradually to the very acute point with a constriction about one-third its length from the extremity, which reaches slightly beyond the apex of the exopod.

In the 3rd, 4th and 5th pleopods (fig. 28), the exopods are similar in general appearance to those of the 1st and 2nd, and the endopods show the usual branchial structure and have the margins free from setae.

In none of the exopods is there a special respiratory tree-like structure or "trachea," but probably there are special modifications which enable them to act as organs for breathing dry atmospheric air as is the case in *Oniscus* (see Stoller, 1899, p. 24).

The terminal segment and the uropods agree with the description given by Budde-Lund and are on the whole similar to the figure given by Dollfus for his *Anomaloniscus ovatus*.

Hemiporcellio carinatus, Collinge.

(Figs. 29 to 32).

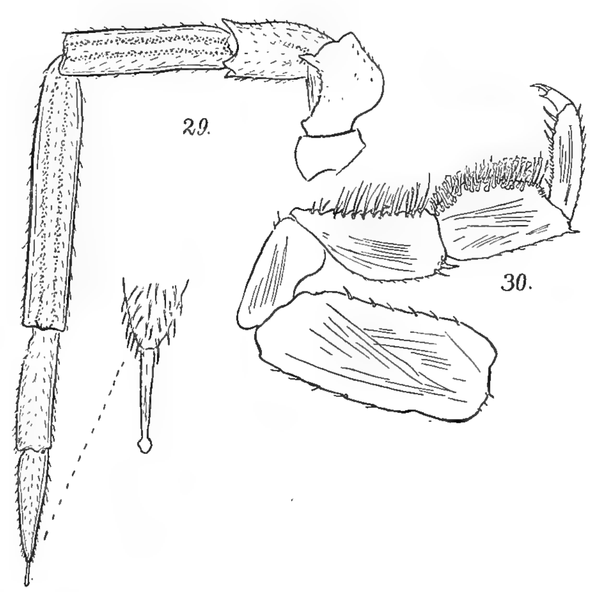
Hemiporcellio carinatus, Collinge, 1915, p. 145, pl. vi, figs. 1-10.

Barkuda Island, Lake Chilka Survey, Station 26. No. $\frac{8796}{10}$. Two specimens.

I have no hesitation in referring these two specimens to the above species, the type of which was collected at Rambha under stones, etc., at the edge of Lake Chilka.

The species is placed by Collinge in the new genus *Hemiporcellio*, which includes a closely allied species *H. hispidus*, Collinge, also from Lake Chilka district, and *H. immsi* (Collinge) from Allahabad. As yet, however, no diagnosis of the genus as distinct from the species has been given.

The two specimens now under consideration agree well with the description and figures given by Collinge. One that I have partially dissected proves to be a male, and I am therefore able to give the sexual characters.



Hemiporcellio carinatus, Collinge.

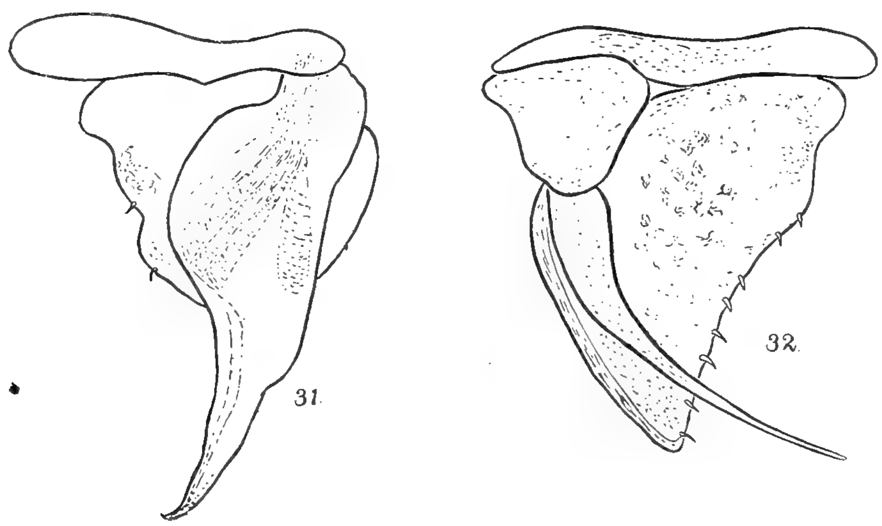
Fig. 29.—Second antenna.

Fig. 30.—First leg of male.

The legs are all nearly of the same length, the seventh pair being only slightly longer than the first. In the first (fig. 30) the carpus is slightly expanded and bears on the inner margin a very dense covering of setae, most of which are slightly

thickened and irregularly dentate at the end, ending in 2 or 3 points; the inner margin of the merus is also thickly covered with setae, but most of these are more normal in appearance, ending acutely; the propod bears only a few setae of normal structure. The second leg is similar to the first, but more slender and the setae on the carpus are fewer and end more acutely in the usual way, while in the third leg there is still less modification, the joints bearing only a few more than the ordinary normal supply of setae. It is probable that the male of *H. hispidus* has similar characters, for Collinge states that "the three terminal joints are fringed with stout spines with trifid terminations," though he does not say whether this is common to all the legs or not.

The first and second pleopoda of the male of *H. carinatus* show characters on the whole similar to those found in other species of *Porcellio*. In the first pleopod (fig. 31) the endopod is nearly twice as long as the exopod, its basal half is broadened,



Hemiporcellio carinatus, Collinge.
FIG. 31.—First pleopod of male. FIG. 32.—Second pleopod of male.

while the distal half narrows to an acute point, the broadened basal portion being filled with an extremely powerful muscle. The second pleopod (fig. 32) has the exopod somewhat more triangular and longer than in the first, its outer margin bears a number of short spinules; the endopod consists of a broad basal joint, subtriangular in shape, followed by a second joint curving outwards to a very acute point and reaching considerably beyond the end of the exopod.

In the antenna the 3rd, 4th and 5th joints of the peduncle are carinated as described by Collinge, and the 2nd, 3rd and 4th have indentations at the end with tooth-like processes between them, as shown in fig. 29. These are apparently similar to those in *H. immsi*, the figure and description of which I had not specially noted until after my figure had been drawn. The 4th joint has a distinct groove on the outer side into which the 5th joint fits when bent back in the usual position. The small process at the end of the terminal joint of the flagellum ends in a slight enlargement.

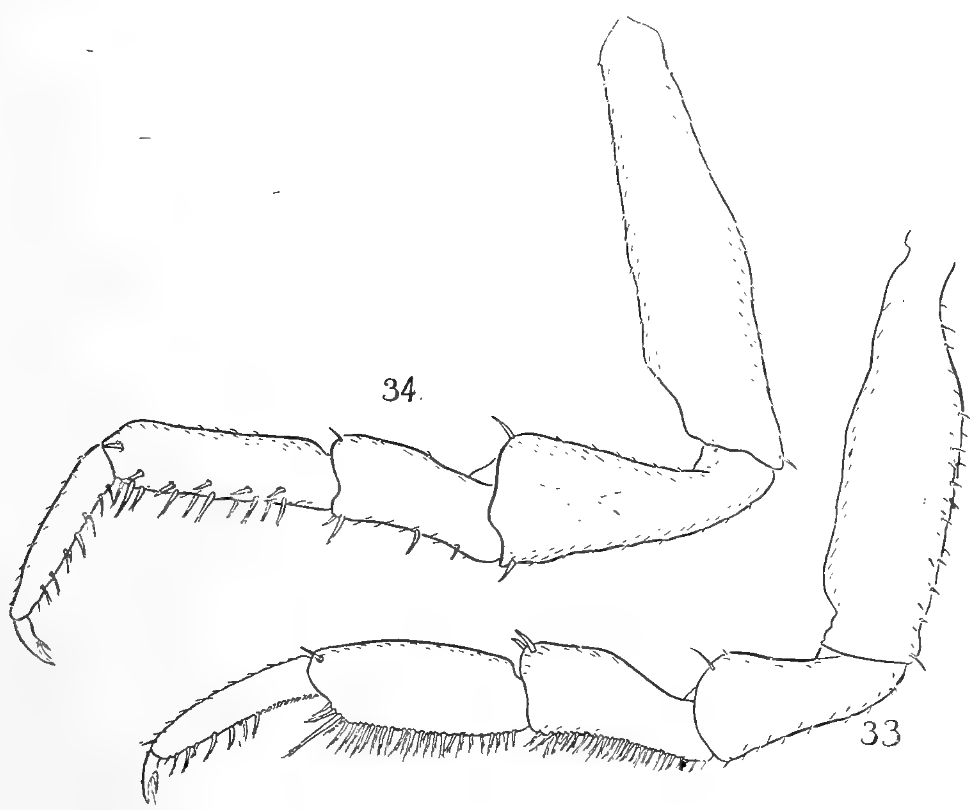
Cubaris granulatus, Collinge.

(Figs. 33 to 36).

Cubaris granulatus, Collinge, 1915, p. 151, pl. xii, figs. 1-11.

Patsahanipur Hill, off Balugaon, Lake Chilka, Orissa, 26-i-14 (*F. H. G.*). Two specimens. No. $\frac{8803}{10}$.

I have little doubt that these two specimens belong to this species, the type specimens of which were collected at Rambha, Lake Chilka. They agree generally with the description and figures given by Mr. Collinge. The surface is nearly smooth, being very finely granular, and the irregular rugosities on the head are not very distinct. The colour (in spirit) is a light olive brown, with the usual lighter markings near the median line.



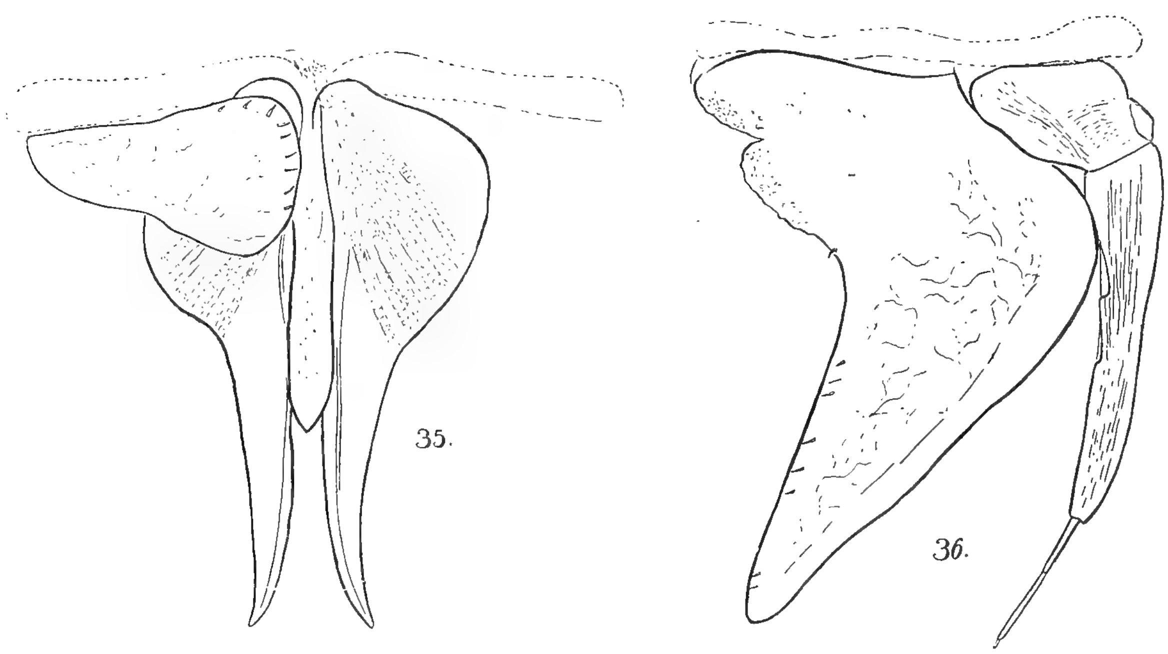
Cubaris granulatus, Collinge.

FIG. 33.—First leg of male. FIG. 34.—Seventh leg of male.

The dense mass of setae on the third and fourth joints of the thoracic appendages described by Mr. Collinge are found only in the male, and on the anterior legs. One of my specimens is a male and shows these setae well developed on the merus and carpus of the first leg (fig. 33), nearly all of the setae being bifid or trifid at the extremities. In the second leg there are similar groups of setae on the two corresponding joints, but they are not quite so numerous as in the first leg, while in the third they are still less numerous and are hardly more noticeable than the ordinary setae on the succeeding pairs of legs, as shown in fig. 34, which represents the seventh leg.

The other specimen is a female and shows only the ordinary number of setae, even on the anterior pairs of legs.

The first and second pleopods of the male are shown in figures 35 and 36, and on the whole correspond with those found in allied genera. In the first pleopod (fig. 35) the exopod is quite small, while the endopod is developed into a very large, strongly chitinised and powerful appendage, swollen at the base, which is occupied by a large muscle, and ending distally in an acute point curving slightly outwards; the male organ proper is only about half as long as the endopod, has the sides nearly parallel and ends in a subacute point. In the second pleopod (fig. 36) the exopod is much larger, being as long as the modified endopod, and tapers to a long triangular process distally; it is lobed on the outer margin near the base at the position of the air cavity, the lobes apparently having a roughened surface; there are a few, very small, setae along the distal portion of the outer margin. The endopod has the shape shown in figure 36, its terminal portion being very narrow.



Cubaris granulatus, Collinge.

FIG. 35.—First pleopod of male. FIG. 36.—Second pleopod of male.

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FAUNA OF THE CHILKA LAKE

OLIGOCHAETA.

(Supplementary Report).

By J. STEPHENSON, *D.Sc., Lt.-Col., I.M.S., Professor of Zoology, Government College, Lahore.*

(With 1 text-figure).

CONTENTS.

OLIGOCHAETA.

(*Supplementary Report*).

By J. STEPHENSON.

A number of small worms, which proved to be of the above species, were kindly sent to me for examination a short time ago by Dr. Annandale. The species has hitherto been recorded, so far as I have been able to discover, by only two observers,—Ditlevsen, who found it in Denmark, and Moore, in the United States. The genus to which it belongs, however, has also been found in England, Japan, the Kermadec and Auckland Islands, and the Transvaal (I include the identical or closely allied *Rhizodrilus*), and thus is cosmopolitan. From a zoogeographical point of view therefore the present record is not of much importance. The worm is however interesting, inasmuch as the fusion of the originally paired genital apertures in the middle line has here been followed by the disappearance of the spermatheca of the right side.

Monopylephorus parvus, Ditlevsen.

Barkuda I., Chilka Lake, Ganjam Dist., Madras Pres.; among rotting water-weeds at edge of lake (*Annandale* and *Gravely*); 15—22-vii-1916. Numerous specimens.

Two short accounts of the anatomy of this worm have already been given (Ditlevsen, 3; Moore, 6). The following description is fairly complete, and adds a number of particulars, more especially with regard to the setae and genital apparatus.

The maximum length of the specimens was half an inch, or about 12 mm., and their thickness about ·35 mm. They were whitish or grey in colour (pink during life). The external segmentation was very well marked, the segments being divided by very distinct constrictions, and bulging out between these. The number of segments counted in a good-sized specimen was 64; there were no secondary annulations.

The prostomium is large, prominent, and triangular in shape with rounded tip.

The clitellum embraces about the posterior two-fifths of segment x, and the whole of xi and xii.

The setae are of two forms, single-pointed and double-pointed curved needles (crotchets); both kinds occur in both dorsal and ventral bundles. There are no hair-setae.

The double-pointed needles (fig. 1*a*) are 80μ in length,—those of the anterior bundles perhaps a trifle longer; in thickness they are about 3μ. The nodulus is somewhat distal to the middle of the shaft. The prongs are equal in length, or the outer may sometimes seem to be slightly the longer, and both are comparatively short; anteriorly, the rule is that the prongs are nearly equal in thickness, but the

relation varies, so that in some cases the outer prong is only two-thirds as thick as the inner, while towards the posterior end it may be only half as stout.

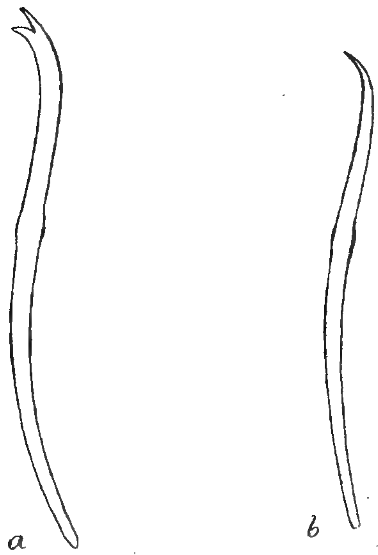

FIG. 1.—*Monopylephorus parvus*, Ditlevsen.

a. Double-pointed seta from an anterior dorsal bundle. × 760.
b. Single-pointed seta from a ventral bundle behind the middle. × 760.

The single-pointed needles (fig. 1*b*) are about 70μ or a little more in length, and 3μ in thickness. They have the usual double curve, the distal curve however being more marked than the proximal. They end in a single sharp point; and the nodulus is slightly distal to the middle of the shaft.

A certain number of double-pointed setae are found in which the outer prong is small. Thus they present an intermediate character; and the single-pointed setae may be conceived as originating from the double-pointed by the diminution and ultimate loss of the outer prong.

The ventral setae begin in segment ii, and are absent in xi. They are usually three per bundle throughout the body, including the hinder end, but in the anterior segments four and five are met with. The bundles are composed of only double-pointed setae throughout the anterior half of the body; single-pointed setae are found behind the middle, and at first only occasionally; they are commoner at the hinder end, but even there are outnumbered by the double-pointed.

The dorsal setae begin in segment ii; the number per bundle is here also three, four, or five;—three in one or two of the most anterior segments, then four or five as far as the clitellum, and thenceforward three or four,—more usually three, at any rate in the hinder part of the body. In the most anterior segments only double-pointed setae are found; these soon begin to be replaced by the single-pointed, and the change is completed shortly behind the clitellum, or, in another specimen, by about the middle of the body. The dorsal thus differ from the ventral bundles in the much greater proportion of the single-pointed setae.

The alimentary tube is but little differentiated into distinct regions. Chloragogen cells begin in segment vi, and thereafter the characters of the canal remain much the same throughout the body. The pharynx is remarkable for the height of the epithelium on the roof; an area of columnar cells, with an abrupt margin, forms a plate-like or sucker-like projection into the cavity, and exactly resembles the structure called the "pharynx" in the Enchytraeidae. The "pharyngeal gland cells" are arranged in four cords which are applied dorsally and dorso-laterally to the pharynx, as described and figured for *M. limosus* by Nomura (7). Numerous similar cells are found on the body-wall, where they form considerable masses at the level of the hinder part of these cords, as well as for some distance behind this, as far as segment vi; a number are also seen on each side of the ventral nerve cord in the oesophageal region.

The body-cavity corpuscles have the characters described by Moore (6); a fairly large one is 10μ in diameter.

The dorsal vessel is ventro-laterally or laterally situated, on the left side of the alimentary tube, throughout the greater part of the body; it appears in a mount of the whole animal as a series of loops, the bend of each loop being at about the level of the lateral line of the body and the rest of the vessel below this level; it becomes altogether lateral in position about segment vii, and is only really dorsal at the anterior end of the body. Supra- and subintestinal vessels are absent. The parietal plexus is situated amongst the muscular fibres of the body-wall, well beneath the peritoneal layer. The valves in the larger vessels have been described in related species by previous authors (Goodrich, 4; Nomura, 7).

The Enchytraeid character of the nephridia in this genus is well known. The remarkable length of the upper lip of the funnel is not to be made out in preserved material.

The anterior lobes of the cerebral ganglion project forwards for some distance,—about 30μ,—in front of the main mass; there are practically no posterior projections.

The testes are situated in segment x, along with the cup-shaped funnels and a quantity of sperm-morulae. The vas deferens is at first, immediately behind the septum, 25μ in diameter, and without any covering of high peritoneal cells; but this uncovered portion is of very small extent,—scarcely even as long as the width of the tube.

The second portion of the duct, or the part which is covered with elongated peritoneal cells, passes backwards for some distance ventrally in the segment, and then rises towards the dorsal body-wall. The investment of high cells ceases just before the tube reaches the highest point of its course. In this part of its extent the canal with its investment has a diameter of 90 to 120μ by 50μ; the central tube is about 35μ thick, the peritoneal covering accounting for the remainder. The cells composing the wall of the tube are columnar, about twice as high as broad, and furnished with long cilia; the peritoneal cells are apparently only one layer thick, and very much elongated,—sometimes as much as 40μ in length; where they appear to be more than one layer thick the section is probably oblique; their cytoplasm stains darkly and equably, and the nucleus is at about half the height of the cell.

The third portion of its course, which is free from the tall peritoneal investment, comprises the summit of the curve and the downward course of the canal until it joins the atrial chamber. Its total length is about 100μ, and its diameter at first 35 to 40μ, but it becomes narrower before joining the atrial chamber, measuring at its end 23μ; from the bend downwards it is heavily ciliated.

The atrial chamber is of an elongated pear-shape, the narrower end below; the lower ends of both converge to unite in the middle line, and forming there a narrow tube, discharge, as described by Moore, on the summit of a low papilla on the roof of the spermiducal chamber; the union of the atrial chambers takes place below the ventral nerve cord and ventral vessel. Each atrial chamber is 145μ long and 70μ in diameter at its thickest part; its upper end is at about half the height of the segment; it is lined by a very high non-ciliated columnar epithelial layer, so that the clear lumen in the middle is not more than about 20μ across. There are well-marked circu-

lar (inner) and longitudinal (outer) muscular investing layers; and the covering of peritoneal cells cannot be described as either tall or flat.

The spermiducal chamber is a median depression on the ventral surface, squarish in shape as seen in a transverse section of the animal, its depth and width about 40μ. It is lined by cubical epithelium.

A single sperm-sac, an anterior evagination of septum 9/10, is situated in segment ix; and a posterior sperm-sac, also single, extends backwards through several segments from septum 10/11.

The ovary and ovisac have the usual positions; but I did not see any trace of oviduct or ovarian funnel.

The spermatheca is single, in segment x. Its external opening is in the middle line in furrow 9/10; but the organ belongs to the left side. It lies near the ventral body-wall, and takes up nearly the whole of the segment in an antero-posterior direction. It may be described as a somewhat twisted cylinder, whose diameter reaches 80μ, narrowing towards the external aperture to form a short duct which bends downwards. The spermatozoa, which form an amorphous mass, not spermatophores, are contained in the most posterior (ental) part of the chamber. Here the epithelial lining is cubical; the middle portion of the organ, much larger than the former, but not separated from it by any distinct constriction, is lined by a columnar epithelium with the nuclei basal; the duct has a lining of approximately cubical cells.

Remarks. I subjoin a comparison of certain features of this worm with the specimens described under the above name by Ditlevsen and Moore.

Ditlevsen gives no indication of the habitat of his worm. Moore's was a littoral form; "it appears to prefer more gravelly shores and the neighbourhood of beach grass, among the roots of which it may be found. In a few cases larger numbers were found living gregariously between stones at half-tide on the south shore of Naushon." The related species *M. glaber* (Moore, 6) flourishes best in brackish water; enormous numbers were found where the saltness of the water was just barely perceptible to the taste. Dr. Annandale informs me that the salinity where the present specimens were found was certainly low, but the water was distinctly brackish. At the same place on the same date in 1914 the specific gravity was 1·0145 (corrected).

The segments in the specimens here described were not, as in Moore's worm, quadriannulate.

The differences in the setae are more important. According to Ditlevsen, while the hinder dorsal bundles contain single-pointed setae, all the ventral setae are bifid. Moore finds the tips "curiously variable," and single-pointed tips seem to have been very much the exception ("in some the tips are deeply bifid and the points long and acute; others, especially in the posterior dorsal bundles, have the upper or distal point more or less reduced, and still others have a more apical notch or are apparently entire"). In the present specimens all the dorsal setae behind the middle of the body, and some in front of this, are single-pointed, while single-pointed setae are not uncommon in the posterior ventral bundles also; intermediate forms are comparatively rare.

The abnormal position of the dorsal vessel is not mentioned by either author; it is shown lying against the side of the intestine in Moore's figure. It is said to be on the *right* side in *M. limosus* by Nomura (7).

Ditlevsen implies, and his figure shows, that the two male ducts do not unite before entering the spermiducal chamber; nor is there any reference to the widening to the duct which I have called the atrial chamber; this latter, however, is visible in the figure.

There can, I think, be little doubt that Moore's specimens are specifically identical with those here described; but I am inclined to agree with him that further information may necessitate a separation between Ditlevsen's worm and his own. As to the generic name that should be employed; Benham (1, 2), uniting *Rhizodrilus* and *Monopylephorus*, uses the former; Michaelsen (5), while accepting the union, prefers the name *Monopylephorus*; Nomura (7) gives reasons for retaining the two genera as distinct. A revision of all the forms described under these two names is, as Michaelsen says (*loc. cit.*), required, along with that of related genera; for the present the most convenient course seems to be to retain the name under which the worm has already twice been described.

A thorough revision would also probably indicate the homologies of the various parts of the male efferent apparatus with the successive segments of the tube in other genera. At present there is an extraordinary amount of confusion: Ditlevsen calls the whole tube, from the funnel to its termination in the median pit on the ventral surface, "Samenleiter" (=vas deferens); the pit itself, following Goodrich, he names "spermiducal chamber" (using the English words). Moore uses the term "sperm reservoir" for the portion of the duct which is covered by high peritoneal cells, "ejaculatory duct" for the short succeeding portion, and "median bursa" for the pit on the surface; the term "penis sac" is employed for the dilatation which I have called "atrial chamber." There is, however, no such dilatation of the "sperm reservoir" as would lead one to suppose that it is capable of acting as such, nor did I find spermatozoa in this portion of the duct; while the epithelium of the "penis sac" is so high that the passage would be altogether obliterated by the eversion or even by any considerable protrusion of the terminal portion of the apparatus; the utmost that could happen, apparently, would be some slight protrusion of the papilla on the roof of the "median bursa," sufficient, perhaps, to bring this level with the surface of the body. Nomura, in describing *M. limosus*, uses the term "atrium" for the portion of the duct which is covered by high peritoneal cells, "atrial duct" for the short portion which succeeds, and "lateral horn of the spermiducal chamber" for what I have called the "atrial chamber." Michaelsen, in *M. africanus*, includes under the term "atrium" the atrial duct of Nomura; in this species there is apparently no separate "atrial chamber," the upper part of the deep "Kopulationstasche" (spermiducal chamber, median bursa) representing the united atrial chambers of such forms as *M. parvus, glaber, limosus*, etc.; but on other grounds (spermathecae in segment ix, presence of penial setae) it seems probable that *M. africanus* ought to be considered as belonging to another genus. Most authors seem to confine the term

"vas deferens" to that part of the duct in front of the covering of high peritoneal cells; in the present case the "vas deferens" would be almost, and in *Rhizodrilus kermadecensis* (Benham, 2), where the covering begins immediately behind the funnel, it would be altogether absent. Merely from a consideration of the present form, it would seem pretty obvious that the whole duct from funnel to atrial chamber corresponds to the "vas deferens" in the Tubificidae and Naididae generally; but, as I have said, comparative studies are necessary to settle the terminology. I hope the terms I have employed are sufficiently non-committal to obviate any further confusion.

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(1) Benham, W. B.—Report on Oligochaeta of the Subantarctic Islands of New Zealand, 1909.

(2) *ib.* Oligochaeta from the Kermadec Islands. *Trans. New Zealand Inst.*, vol. xlvii, 1914.

(3) Ditlevsen, A.—Studien an Oligochaeten. *Zeitsch. f. wiss. Zool.*, vol. lxxvii, 1904.

(4) Goodrich, E. S.—On the structure of *Vermiculus pilosus*. *Quart. Journ. Micr. Science*, n. s., vol. xxxvii, 1895.

(5) Michaelsen, W.—Oligochäten von tropischen und südlichsubtropischen Afrika. *Zoologica*, Heft 67 u. 68, 1912-1913.

(6) Moore, J. P.—Some marine Oligochaeta of New Zealand. *Proc. Acad. Sci. Philadelphia*, vol. lvii, pt. ii, 1905.

(7) Nomura, E.—On the aquatic Oligochaete *Monopylephorus limosus* (Hatai). *Journ. Coll. Sci. Tokyo*, vol. xxxv, 1915.

FAUNA OF THE CHILKA LAKE.

FISH.

PART III.

By B. L. CHAUDHURI, *D.Sc.* (*Edin.*), *F.R.S.E.*, *F.L.S*

(With 2 text-figures).

CONTENTS.

FISH. (*PART III*).

By B. L. CHAUDHURI.

This part contains a systematic treatment of the suborders Percesoces and Plectognathi of the order Teleostei. The total number of specimens examined and recorded is 373. They belong to twenty species. Of these one (*Sphyraena raghava*) is new to science. The twenty species fall into nine genera and seven families.

Suborder PERCESOCES.

Family SCOMBRESOCIDAE.

Genus **BELONE,** Cuvier

Belone strongylura, Van Hasselt.

1803. *Esox* sp. (*Kuddera A.*), Russell, *Fish Vizag.* II, p. 61, pl. clxxvi.
1823. *Belone strongylura*, Van Hasselt, *Alg. Konst. Letterbode*, p. 131.
1823. *Belone strongylura*, *Id.*, *Bull. Ferussac Zool.*, p. 374.
1830. *Belone caudimacula*, Cuvier, *Reg. Anim.*, p. 234.
1846. *Belone caudimacula*, Cuvier and Vallenciennes, *Hist. Nat. Poiss.*, XVIII, p. 452.
1846. *Belone caudimacula*, Richardson, *Rep. Brit. Assc. Adv. Sc.* (1845), p. 264.
1849. *Belone caudimacula*, Cantor, *Journ. Asiat. Soc. Bengal* (1849), p. 1228.
1851. *Belone caudimaculata*, Jerdon, *Madras Journ. Lit. Sc.*, p. 147.
1853. *Belone caudimacula*, Bleeker, *Verh. Bat. Gen.*, XXV, p. 72.
1865. *Belone caudimaculata*, Day, *Fish. Malabar*, p. 165.
1866. *Mastacembelus strongylurus*, Bleeker, *Ned. Tijdsch. Dierk.*, III, p. 220.
1866. *Belone strongylura*, Günther, *Cat. Fish Brit. Mus.*, VI, p. 246.
1866. *Belone caudimaculata*, *Id.*, *ibid.*, p. 245.
1872. *Mastacembelus strongylurus*, Bleeker, *Atl. Ich. Ind. Orient. Neerl.*, VI, p. 45, pl. cclvii, fig. 3.
1878. *Belone strongylurus*, Day, *Fish. Ind.*, p. 512, pl. cxviii, fig. 6.
1889. *Belone strongylura*, Day, *Faun. Brit. Ind. Fish.*, II, p. 421.
1910. *Belone strongylura*, Jenkins, *Rec. Ind. Mus.*, V, p. 131.
1913. *Belone strongylura*, Weber, *Fisch. Siboga-Exped.*, p. 122.

There are ten specimens in the collection, the largest of which measures 410 mm. in length. It was collected at Parikud at the end of November, 1914. The rest vary from 224 mm. to 328 mm. in length and were collected at Satpara and Rambha Bay, mostly during the latter part of July, 1913. The species does not breed in the lake and appears to be only an occasional visitor to it.

Distribution:—Coasts and estuaries from Bengal to China; East Indian Archipelago and North Australia; in the river Brunai (Borneo) and in fresh water at Aleppee (Malay Peninsula).

Genus **HEMIRHAMPHUS**, Cuvier.

Hemirhamphus limbatus, Cuvier and Valenciennes.

1846. *Hemirhamphus limbatus*, Cuvier and Valenciennes, *Hist. Nat. Poiss.*, XIX, p. 44.
1849. *Hemirhamphus tridentifer*, Cantor, *Journ. Asiat. Soc. Bengal* (1849), p. 1231.
1859. *Hemirhamphus brachynotopterus*, Blyth, *Proc. Asiat. Soc. Bengal* (1858), p. 288.
1878. *Hemirhamphus limbatus*, Day, *Fish. Ind.*, p. 516, pl. cxix, fig. 3.
1889. *Hemirhamphus limbatus*, *Id.*, *Faun. Brit. Ind. Fish.*, II, p. 426.

There are eighty-eight specimens in the collection, many of which are quite young. They were obtained throughout the year and from all parts of the lake. The species is a permanent inhabitant and breeds in the lake at least twice in the year. In full-grown specimens the caudal fin is truncate in some and lunate in others; in most of the specimens the lower caudal lobe is the longer.

In Hamilton Buchanan's volume of manuscript drawings,[1] plate xcv is identified as a figure of *H. limbatus*, but it is not described anywhere by him.

The following statement gives the different localities whence the specimens were collected, and their number and size.

1 specimen	Off Balugaon	6-iii-14	measuring 10 mm.
1 ,,	Between Barkuda Island and the mainland	16-vii-14	,, 33 ,,
6 specimens	Off Barkul	13-xi-12	,, 42 ,, to 105 mm.
3 ,,	Chiriya Island	17-xi-14	,, 10 ,, to 11 ,,
1 specimen	Between Guntasila and Breakfast Island	23-xi-14	,, 32 ,,
1 ,,	Off Guntasila	18-xi-14	,, 98 ,,
2 specimens	Off Kalidai	5-iii-14	,, 83 ,, and 95 mm.
2 ,,	,, ,,	21-ix-14	,, 4 ,, and 8 ,,
10 ,,	,, ,,	22-xi-14	,, 5 ,, to 10 mm.
17 ,,	Between Kalidai and Samalkuda	21-xi-14	,, 4 ,, to 40 ,,
8 ,,	Off Kalupara Ghat	16-ix-14	,, 40 ,, to 62 ,,
1 specimen	Off Nalbano	18-ix-14	,, 83 ,,
2 specimens	Off Manikpatna (close to sand dunes opposite)	3-ix-14	,, 18 ,, and 61 mm.
8 specimens	Off Patsahanipur	6-iii-14	,, 10 ,, to 95 ,,
5 ,,	,, ,,	10-iii-14	,, 53 ,, to 165 ,,
3 ,,	Rambha Bay	Feb. 14	,, 24 mm., 85 mm. and 99 mm.
5 ,,	,, ,,	15-ii-14	,, 10 ,, to 15 mm.
11 ,,	,, ,,	23-ix-14	,, 7 ,, to 18 ,,
1 specimen	Off Sankuda	17-ii-14	,, 140 ,,

This is one of the most extensively used food-fishes of the lake.

Distribution :—Indian Ocean; sea of Penang; this is by far the most common species on the Coromandal coast of India and extends to Burma; it is also found, but more rarely, on the Malabar coast; it ascends tidal rivers and is sometimes captured in fresh waters.

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[1] Chaudhuri, *Mem. Ind. Mus.*, V, p. 444 (foot-note).

Family MUGILIDAE.

Genus MUGIL, Linnaeus.

Mugil cephalus, Linnaeus.

1758. *Mugil cephalus*, Linnaeus, *Syst. Nat.* Ed. X, p. 316.
1775. *Mugil Öûr*, Forskål, *Descrip. Anim.*, p. xiv, no. 109c.
1788. *Mugil cephalus*, Bonnaterre, *Tabl. Encyclop.*, p. 179, pl. lxxiii, fig. ccciv.
1801. *Mugil cephalus*, Lacepede, *Hist. Poiss.*, V, p. 384.
1835. *Mugil Öûr*, Ruppell, *Neu. Wirbel. Fisch.*, p. 131.
1836. *Mugil cephalotus*, Cuvier and Valenciennes, *Hist. Nat. Poiss.*, XI, p. 110.
1841. *Mugil cephalotus*, Eydoux and Souleyet, *Voy. Bonite, Zool.*, I, p. 175, pl. iv, fig. 4.
1842. *Mugil cephalotus*, Cantor, *Ann. Mag. Nat. Hist.*, IX, p. 484.
1845. *Mugil japonicus*, Temminck and Schlegel, *Faun. Japon.*, p. 134, pl. lxxii, fig. 1.
1845. *Mugil cephalotus*, Bleeker, *Nat. Geneesk. Arch. Ned. Ind.*, II, p. 514.
1846. *Mugil macrolepidotus*, Richardson, *Rep. Brit. Assc. Adv. Sc.* (1845), p. 249.
1861. *Mugil cephalotus*, Günther, *Cat. Fish. Brit. Mus.*, III, p. 419.
1865. *Mugil cunnesius*, Day, *Fish. Malabar*, p. 136.
1868. *Mugil cephalotus*, Kner, *Reis. Oster. Novar. Fisch.*, p. 224.
1870. *Mugil oeur*, Klunzinger, *Verhand. zool. bot. Gesell. Wien*, XX, p. 829.
1878. *Mugil oeur*, Day, *Fish. Ind.*, p. 353, pl. lxxv, fig. 3.
1889. *Mugil oeur*, *Id.*, *Faun. Brit. Ind. Fish.*, II, p. 348, fig. 114.
1903. *Mugil cephalus*, Fowler, *Proc. Acad. Nat. Sc. Philadel.*, LV, p. 743.
1907. *Mugil cephalus*, Jordan and Seale, *Proc. Davenport Acad. Sc.*, X, p. 4.
1911. *Mugil oeur*, Jordan and Richardson, *Mem. Carnegie Mus.*, IV, p. 176.
1916. *Mugil cephalus*, Waite, *Trans. Proc. Roy. Soc. South Australia*, XL, p. 453.

As yet no characters separating this Indian species from the cosmopolitan *Mugil cephalus* have been pointed out [1]; it is identical with the Japanese species *M. öeûr*, *M. cephalotus* and *M. japonicus*.

There are seven specimens in the collection, the largest of which measures 309 mm. in length. It was secured at Nalbano on 25-xi-14; five specimens were obtained at Parikudh (21-31-vii-13), measuring 152 mm., 195 mm., 244 mm., 256 mm. and 261 mm. The remaining specimen was secured at the south end of the lake, its length being 208 mm.

The eyes of all the specimens appear slightly smaller than usual in the species. The species probably does not breed in the lake but is an occasional visitor to it.

Distribution :—The Pacific and the Atlantic coasts of America; the Mediterranean sea; coast of Madeira; west coast of Africa; Red sea; Polynesia and Indian Ocean; seas of China and Japan including estuaries and canals.

Mugil gymnocephalus, Swainson.

1803. *Mugil* sp. (*Bontah*), Russell, *Fish. Vizag.* II, p. 64, pl. clxxx.
1839. *Mugil gymnocephalus*, Swainson, Lardner's *Cab. Cyclop. Nat. Hist.* (*Fish. Amph. Rep.*), II, p. 234.
1857. *Mugil belanak*, Bleeker, *Nat. Tijdsch. Ned. Ind.*, XIII, p. 337.

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[1] Jordan and Seale, *Proc. Davenport Acad. Sc.* X, p. 4.

1861. *Mugil belanak*, Günther, *Cat. Fish. Brit. Mus.*, III, p. 427.
1878. *Mugil belanak*, Day, *Fish. Ind.*, p. 351, pl. lxxiv, fig. 5.
1889. *Mugil belanak*, *Id.*, *Faun. Brit. Ind.*, *Fish.*, II, p. 345.
1905. *Mugil belanak*, Fowler, *Proc. Acad. Nat. Sc. Philadel.*, LVII, p. 494, fig. 9.

Russell's figure and description of his *Bontah* (pl. clxxx), which he wrongly identified as *M. cephalus*, L., was adopted by Swainson in 1839 as representing his *M. gymnocephalus*. This name has, therefore, priority over the rest. Russell's name *Bontah* was adopted by Bleeker for his *Mugil bontah* [1], but the latter placed specimens of another species under that name.[2] Day was misled by Russell's adoption of the name *Mugil cephalus* for his *Bontah* into the belief that this species was identical with *Mugil ôûr*, Forskål.

There is only one specimen in the collection. It measures 88 mm. in length and was obtained in the latter part of July, 1913. The fish is a casual visitor to the lake.

Distribution :—Seas of India ; coasts and rivers of the East Indian Archipelago ; Malay Archipelago.

Mugil cunnesius, Cuvier and Valenciennes.

1803. *Mugil* sp. (*Kunnesee*), Russel, *Fish. Vizag.* II, p. 65, pl. clxxxi.
1836. *Mugil cunnesius*, Cuvier and Valenciennes, *Hist. Nat. Poiss.*, XI, p. 114.
1837. *Mugil cunnesius*, Ruppell, *Neu. Wirbel. Fisch.*, p. 131.
1839. *Mugil squamipinnis*, Swainson, Lardner's *Cab. Cyclop Nat. Hist.* (*Fish. Amph Rep.*), II, p. 414.
1845. *Mugil cunnesius*, Bleeker, *Nat. Geneesk. Arch. Ned. Ind.*, II, p. 514.
1849. *Mugil cunnesius*, Cantor, *Journ. Asiat. Soc. Bengal*, p. 1082.
1858. *Mugil axillaris*, Bleeker, *Nat. Tijdsch. Ned. Ind.*, XVI, p. 280.
1861. *Mugil longimanus*, Günther, *Cat. Fish. Brit. Mus.*, III, p. 428.
1861. *Mugil cunnesius*, *Id.*, *ibid.*, p. 434.
1865. *Mugil engli*, Day, *Fish. Malabar*, p. 139.
1878. *Mugil cunnesius*, Day, *Fish. Ind.*, p. 349, pl. lxxiv, fig. 3.
1889. *Mugil cunnesius*, *Id.*, *Faun. Brit. Ind. Fish.*, II, p. 342.
1909. *Mugil cunnesius*, Jenkins, *Rec. Ind. Mus.*, III, p. 287.
1910. *Mugil cunnesius*, *Id.*, *ibid.*, V, p. 133.

There are one hundred and seventy-six specimens in the collection. Of these one hundred and seventy four are very young, measuring from 35 mm. to 70 mm., and the remaining two are adult : *viz.* one from Satpara measuring 118 mm. in length, and one from Barkul measuring 129 mm. in length. The young specimens were caught in prawn-traps and nets during the third week of September, 1914. This fish evidently breeds in the lake, probably from the beginning of the breaking up of the monsoons. Cantor noted the young to be numerous at all seasons at Penang. The fish is a permanent inhabitant of the lake, in the main area as well as in the outer channel, breeding freely in the main area, at least at the commencement of the rains if not at "all seasons."

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[1] Bleeker, *Verh. Bat. Genoot.*, XXV, p. 48 (1853).
[2] Bleeker, *Nat. Tijdsch. Ned. Ind.*, XIII, p. 336 (1857).

Distribution :—Abyssinia ; Red sea ; seas of India to the Malay Archipelago and beyond.

Mugil subviridis, Cuvier and Valenciennes.

1836. *Mugil subviridis,* Cuvier and Valenciennes, *Hist. Nat. Poiss.,* XI, p. 115.
1836. *Mugil dussumieri, Id., ibid.,* p. 147,
1861. *Mugil subviridis,* Günther, *Cat. Fish. Brit. Mus.,* III, p. 423.
1865. *Mugil subviridis,* Day, *Fish. Malabar,* p. 138.
1878. *Mugil dussumieri,* Day, *Fish. Ind.,* p. 352, pl. lxxiv, fig. 4.
1878. *Mugil subviridis, Id., ibid.,* p. 353.
1884. *Mugil dussumieri, Id., Faun. Brit. Ind. Fish.,* II, p. 347.
1889. *Mugil subviridis, Id., ibid.,* p. 348.

There are three specimens in the collection, two from Satpara measuring 143 mm. and 130 mm. in length, the latter being secured in March, 1914. The remaining specimen, measuring 85 mm., was obtained at the mouth of Barkul Bay on the 18th September, 1917.

There is a manuscript figure (named *Mugil laevis* on the margin) in Hamilton Buchanan's drawings which represents this species.

This fish is found in the main area as well as in the outer channel and in all probability is a permanent inhabitant of the lake.

Distribution :—Seas of India, entering fresh water.

Mugil caeruleo-maculatus, Lacepede.

1798. *Mugil caeruleo-maculatus,* Lacépède, *Hist. Poiss.,* V, pp. 385, 389.
1836. *Mugil caeruleo-maculatus,* Cuvier and Valenciennes, *Hist. Nat. Poiss.,* XI, p. 128.
1860. *Mugil caeruleo-maculatus,* Bleeker, *Act. Soc. Sc. Indo-Neerl.,* VIII, *Sumatra* (IX), p. 5.
1861. *Mugil caeruleo-maculatus,* Günther, *Cat. Fish. Brit. Mus.,* III, p. 445.
1878. *Mugil caeruleo-maculatus,* Day, *Fish. Ind.,* p. 356.
1889. *Mugil caeruleo-maculatus, Id., Faun. Brit. Ind. Fish.,* II, p. 351.
1913. *Mugil bleekeri* (in part), Weber, *Fisch. Siboga-Exp.,* p. 139.

There is only one specimen in the collection. It measures 106 mm. in length and was obtained from the outer channel near Satpara in October, 1914. The species is in all probability an occasional visitor to the lake.

Distribution :—Coasts of Mauritius; Bombay, through the seas of India to the Malay Archipelago.

Mugil jerdoni, Day.

1865. *Mugil sundanensis,* Day, *Fish. Malabar,* p. 138.
1878. *Mugil jerdoni,* Day, *Fish. Ind.,* p. 352.
1889. *Mugil jerdoni, Id., Faun. Brit. Ind. Fish.,* II, p. 346.

There are only two specimens in the collection. They measure 105 mm. and 95 mm. in length. Both were secured at Rambha on 31-xii-14. The fish is probably a casual visitor to the lake and is found in the main area at least during the period of maximum salinity. It is a small-sized marine *Mugil* not growing bigger than six inches in length.

Distribution :—Seas of India.

Mugil speigleri, Bleeker.

1858. *Mugil speigleri*, Bleeker, *Act. Soc. Sc. Indo-Neerl.*, V, p. 2.
1860. *Mugil speigleri*, *Id.*, *ibid.*, VIII, p. 58.
1861. *Mugil speigleri*, Günther, *Cat. Fish. Brit. Mus.*, III, p. 435.
1865. *Mugil suppositus*, Day, *Fish. Malabar*, p. 143.
1868. *Mugil axillaris*, Kner, *Reis. Oster. Novar. Fisch.*, p. 227, pl. ix, fig. 93.
1878. *Mugil speigleri*, Day, *Fish. Ind.*, p. 348, pl. lxxiv, fig. 1.
1889. *Mugil speigleri*, *Id.*, *Faun. Brit. Ind. Fish.*, II, p. 342.

There are four specimens in the collection: one from Satpara collected in September, 1914 measuring 110 mm., and three from Rambha obtained at the end of the month of December, 1914 measuring from 117 mm. to 130 mm. This fish is found in the outer channel after the floods are over, and in the main area of the lake in winter.

Distribution:—Seas of India; coasts of Java, Borneo and Halmaheira; Shanghai.

Genus LIZA, Jordan and Swain.[1]

Liza borneensis (Bleeker).

1851. *Mugil borneensis*, Bleeker, *Nat. Tijd. Ned. Ind.*, II, p. 201.
1853. *Mugil adjustus*, *Id.*, *ibid.*, V, p. 503.
1861. *Mugil borneensis*, Günther, *Cat. Fish. Brit. Mus.*, III, p. 448.
1878. *Mugil borneensis*, Day, *Fish. Ind.*, p. 357, pl. lxxvi, fig, 1.
1889. *Mugil borneensis*, Day, *Faun. Brit. Ind. Fish.*, II, p. 353, fig. 115.

There is only one specimen in the collection. It is from Satpara and measures 122 mm. in length. The time of capture is not given. The species appears to be an occasional visitor to the outer channel.

Distribution:—Seas of India; East Indian and Malay Archipelagoes.

Liza corsula (Hamilton Buchanan).

1822. *Mugil corsula*, Hamilton Buchanan, *Fish. Ganges*, pp. 222 and 381, pl. ix, fig. 97.
1836. *Mugil corsula*, Cuvier and Valenciennes, *Hist. Nat. Poiss.*, XI, p. 119.
1841. *Mugil corsula*, Eydoux and Souleyet, *Voy. Bonite, Zool.*, I, p. 172, pl. iv, fig. 2.
1853. *Mugil corsula*, Bleeker, *Verh. Bat. Gen.*, XXV, p. 101.
1860. *Mugil corsula*, *Id.*, *Act. Soc. Sc. Indo-Neerl.*, VII, p. 82.
1861. *Mugil corsula*, Günther, *Cat. Fish. Brit. Mus.*, III, p. 460.
1878. *Mugil corsula*, Day, *Fish. Ind.*, p. 354, pl. lxxi, fig. 6.
1889. *Mugil corsula*, *Id.*, *Faun. Brit. Ind. Fish.*, II, p. 340.
1910. *Mugil corsula*, Jenkins, *Rec. Ind. Mus.*, V, p. 140.

Only one young specimen, 40 mm. in length, is in the collection. It was caught on 16-ix-14 in the north-east portion of the lake about eight miles south-east of Kalupara Ghat, at a point where the depth of the water was eight feet. This specimen was mixed up with other young mullets and its presence was detected only on a minute examination of the specimens. It is remarkable that this species should be represented only by one very young specimen. Probably it entered the lake along with flood-water from the rivers during July, which, judging from the size

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[1] *Proc. U. S. Nat. Mus.*, VII, p. 261 (1884), and *Proc. Acad. Nat. Sc. Philadelphia*, LV, p. 746 (1903).

of the specimen, was about the time when the mother-fish spawned. The species is, however, very common in the brackish and fresh waters of Orissa and individuals are often noticed even in *nayan jhuris* (road-side drains). This fish is proverbially clever in eluding capture and special traps are constructed to secure it. It is not improbable, therefore, that specimens in the lake escape capture. The presence of the species after the freshets is, however, well established, as this individual was captured at a considerable distance from the mouth of any river.

Distribution :—Estuaries and rivers of Bengal, Bihar and Orissa, United Provinces and Burma, found far above tidal influence in fresh water.

Liza troschelii (Bleeker).

1858. *Mugil troschelii*, Bleeker, *Nat. Tijdsch. Ned. Ind.*, XVI, p. 277.
1859. *Mugil troschelii*, *Id.*, *Act. Soc. Sc. Indo-Neerl.*, VIII, *Sumatra* (8), p. 80.
1861. *Mugil troschelii*, Günther, *Cat. Fish. Brit. Mus.*, III, p. 448.
1878. *Mugil troschelii*, Day, *Fish. Ind.*, p. 358.
1889. *Mugli troschelii*, *Id.*, *Faun. Brit. Ind. Fish.*, II, p. 355.
1911. *Liza troscheli*, Jordan and Richardson, *Mem. Carnegie Mus.*, IV, p. 176.
1913. *Mugil troschelii*, Weber, *Fisch. Siboga-Exped.*, p. 139.

There is only one specimen in the collection, 107 mm. in length. It was secured at Satpara; the time of capture is not stated. Probably the fish is only a casual visitor to the outer channel.

Distribution :—Seas of India; coasts of Ceylon, Java, Sumatra and Borneo.

Family POLYNEMIDAE.

Genus **ELEUTHERONEMA**, Bleeker.

Eleutheronema tetradactylum (Shaw).

1803. *Polynemus* sp. (*Maga Jelle*), Russell, *Fish. Vizag.* II, p. 67, pl. clxxxiii.
1804. *Polynemus tetradactylus*, Shaw, *Gen. Zool.*, V, p. 135.
1822. *Polynemus teria*, Hamilton Buchanan, *Fish. Ganges*, pp. 224 and 381.
1829. *Polynemus tetradactylus*, Cuvier and Valenciennes, *Hist. Nat. Poiss.*, III, p. 375, and VII, p. 514.
1839. *Polynemus tetradactylus*, M'Clelland, *Journ. Asiat. Soc. Bengal*, VIII, p. 206.
1839. *Polynemus salliah*, Cantor, *Journ. Roy. Asiat. Soc.*, V, p. 166.
1839. *Polynemus quadrifilis*, *Id.*, *ibid.*, p. 186.
1846. *Polynemus tetradactylus*, Richardson, *Rep. Brit. Assoc. Adv. Sc.* (1845), p. 218.
1849. *Polynemus tetradactylus*, Cantor, *Journ. Asiat. Soc. Bengal*, p. 1007.
1849. *Polynemus tetradactylus*, Bleeker, *Verh. Batav. Gen.*, XXIII, p. 57.
1860. *Polynemus tetradactylus*, Günther, *Cat. Fish. Brit. Mus.*, II, p. 329.
1878. *Polynemus tetradactylus*, Day, *Fish. Ind.*, p. 180.
1880. *Polynemus tetradactylus*, Klunzinger, *Sitzb. Akad. Wien*, LXXX, p. 373.
1889. *Polynemus tetradactylus*, Day, *Faun. Brit. Ind. Fish.*, II, 106.
1903. *Polydactylus rhadinus*, Jordan and Evermann, *Proc. U. S. Nat. Mus.*, XXV, p. 351, fig. 20.
1907. *Polynemus tetradactylus*, Lloyd, *Rec. Ind. Mus.*, I, p. 224.
1911. *Eleutheronema tetradactylum*, Jordan and Richardson, *Mem. Carnegie Mus.*, IV, p. 177, fig. 10.
1913. *Polynemus tetradactylus*, Weber, *Fisch. Siboga-Exped.*, LVII, p. 141.

There are eleven specimens in the collection, among which one from Rambha is fairly large, measuring 430 mm. in length. The species is found throughout the main area of the lake and is a permanent resident, probably breeding near the mouths of rivers before the rains. The following statement shows the different localities whence the specimens were obtained, and their number and size.

2 specimens	Off Balugaon	21-vii-13	130 mm. and 136 mm.
4 ,,	Barkul Bay	18-ix-14	77 mm., 86 mm., 97 mm. and 115 mm.
1 specimen	Off Barkul	———	121 mm.
3 specimens	8 miles S. E. of Kalupara Ghat	16-ix-14	68 ,, to 69 mm.
1 specimen	Rambha	19-xi-14	430 ,,

Distribution:—Seas of India; China; Indo-Australian Archipelago; North-Australia; this species ascends higher up the rivers than any other of the family.

Family SPHYRAENIDÆ.

Genus **SPHYRAENA**, Artedi.

Sphyraena raghava, sp. nov.

(Text-figures 20, 21.)

The body is elongated and round but a little compressed and is also slightly constricted near the end of the caudal peduncle. The dorsal profile is almost straight; the ventral profile is slightly convex to the anterior origin of the anal fin, posterior to which it runs up, narrowing down the depth of the fish to the constricted portion of the caudal peduncle.

The measurements in hundredths of the length without the caudal fin are as follows: the length of the head 31%, the height of the body 14·3%, the length of the snout 15·24%, the horizontal diameter of the eye 5·24%, the length of the maxillary 13%, the breadth of the interorbital space 4·7%, the length of the pectoral fin 10·95%, the length of the ventral fin 7·6%, and the least depth of the caudal peduncle 7·14%.

The distance between the occiput and the anterior origin of the first dorsal fin is equal to the length of the snout; the distance between the anterior origin of the first dorsal fin and the anterior origin of the second dorsal fin is equal to the distance between the anterior origin of the second dorsal fin and the commencement of the caudal fin rays on the superior side of that fin; the distance between the anterior origin of the second dorsal fin and the root of the caudal fin about its middle is equal to the length of the head. The depth of the body is contained seven times in the length without the caudal fin. The least height of the caudal peduncle is half the depth of the body and is contained two and two-thirds times in the length of the caudal peduncle.

The head is long and tapering and is as high as broad. The upper and the lower profiles of the head are straight and the end is pointed. The length of the head measured from the tip of the mandible is contained three and one-fifth times in the length without the caudal fin, and the height of the head, which is equal to the width of the

head and the post-orbital length of the head, is contained three and one-fourth times in the length of the head. The snout is contained twice in the length of the head. The lower jaw is longer than the upper by half the length of the longer diameter of the eye. On the upper side of the free pointed end of the lower jaw there is a fleshy cushion-like protuberance, which is continued over the tip down to the lower surface of the protruded end of that jaw. The anterior end of the upper jaw is truncated and thus fits behind the fleshy cushion on the upper side of the tip of the lower jaw. The skin on the superior side of the truncated end of the upper jaw is finely striated. The eye is large, lateral and ovate; the anterior end of the eye is wider, the vertical diameter being a little more than three-fourths of the horizontal diameter, which is contained six times in the length of the head. The lower margin of the orbit is lower than the middle of the depth of the head. The eyes have adipose eye-lids. The breadth of the interorbital space about the middle of the eyes is contained six and a half times in the length of the head. This space is slightly concave and there are two ridges running through the interorbital space from the end of the snout to the occiput, running more and more apart either way than in the middle of the eyes. The

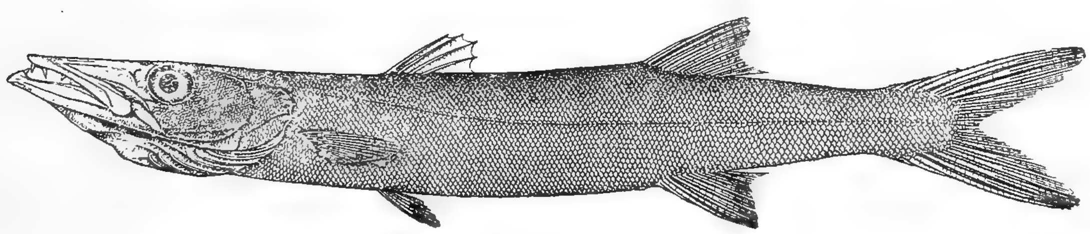

FIG. 20.—*Sphyraena raghava*, Chaudhuri × ½.

two pairs of nostrils are close together, the posterior nostrils are lateral, are in the form of vertically inclined slits and are provided with skin flaps, which are one-third of the vertical diameter of the eye in advance of the anterior orbit; the anterior nostrils are superior in position and are closer together, with tubular openings and are in advance of the anterior orbit by half the horizontal diameter of the eye. The free posterior end of the maxillary is dilated and round and reaches below the posterior nostril of its side; there is a triangular process on the maxillary bone above the angle of the jaws which ends in a bony knob.

The teeth in the jaws are uniserial. At the symphysis of the mandible, just posterior to the fleshy tubercle, there is a pair of large fang-like teeth, placed side by side very close to each other, and inclined together at an acute angle and directed inwards. There is a large round and deep groove correspondingly above at the symphysis of the upper jaw for the lodgment of this pair of canine-like teeth when the mouth is shut. On each side of this pair of teeth, there is an empty round and smooth interval in the jaw on each ramus of the lower jaw, beyond which there are eight minute conical teeth in a single line placed close to one another; posterior to these small teeth there are seven or eight large conical teeth of various sizes quite wide apart from one another, the size of the one further inward being larger than the one

nearer to the symphysis. In the upper jaw, in the front part of the snout, on each side of the large groove at the symphysis already described, there are two large and long fang-like teeth on each side of the groove with a considerable empty interval between. On a higher level to these four fangs there are minute villiform teeth, forty-five in number, on each side on the edges of the premaxillary throughout its length, which continue to the angle of the jaws (as the maxillary bone does not take any part in the formation of the mouth). Further inward and at a lower level, but running parallel to the villiform teeth of the premaxillary, there are on each side a series of palatine teeth beginning behind and beyond the four anterior fang-like teeth. Of these palatine teeth on each side there are four large conical teeth wide apart from one another; posterior to these large conical teeth, but in the same line with them, there are five very small teeth on each side, not very close to one another (fig. 21).

The tongue is not free but is attached to the floor of the mouth about its middle;

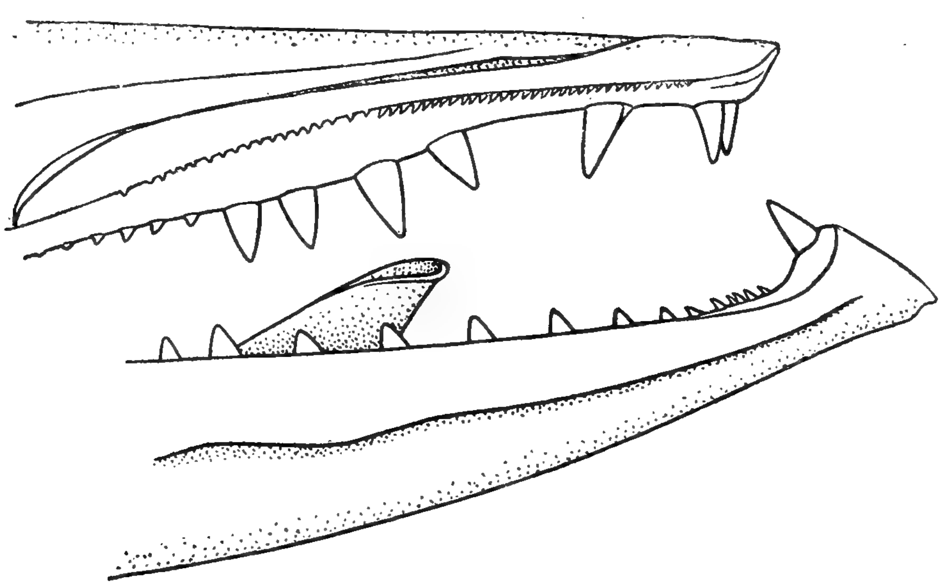

FIG. 21.—*Sphyraena raghava*, Chaudhuri. Teeth of palate, upper and lower jaw.

it is long, slender, and pointed; the upper surface of the tip of the tongue is finely asperous and there are very minute teeth on this surface arranged in longitudinal series.

There are seven branchiostegal rays and the gill openings are wide; the gill rakers are entirely absent and are only represented by the asperities opposite the gill filaments. The pseudo-branchiae are well developed and have about fifty-two filaments, most of which are longer than half the length of the gill filaments. The end of the isthmus is in the form of a hard bony knob. The edge of the operculum is round and is without any spinous process or point.

The dorsal fin has four spines, probably there was another which possibly might have been damaged beyond recognition; the second dorsal fin has one short and slender spine and nine soft rays; the pectoral fin has fourteen rays; the ventral fin has one strong spine and six rays; the anal fin has two spines and nine rays. The distance between the root of the pectoral fin and the anterior origin of the first dorsal

fin is less than the length of the pectoral fin by nearly one-fifth the length of the latter fin ; the insertion of the ventral fin is almost vertically below the anterior origin of the first dorsal fin ; the distance between the root of the ventral fin and the anterior margin of the anal fin is almost equal to the interval between the anterior roots of the two dorsal fins. The anal opening is in advance of the anterior root of the anal fin by half the length of the vertical diameter of the eye. The caudal fin is deeply divided, the length of the middle rays is contained three times in the length of the longest outer caudal rays ; the upper caudal lobe is slightly longer than the lower one.

The scales are small and the head is more or less covered with scales smaller than those on the body. The preorbital, the frontal, and the parietal regions are bare, but the suborbital, the temporal, the occipital, the preopercular and the opercular regions are thickly covered with minute scales. The number of vertical rows of scales on the cheek (below the eye) is nine and the number of vertical rows on the opercle eighteen. The lateral line is complete ; it runs from the upper edge of the gill-opening to the middle point of the base of the caudal fin, consisting of rather large scales perforated by simple tubes ; from the upper corner of the opercular opening the lateral line continues straight along seven scales, then curving a little it slopes below the middle line which it meets traversing forty-three scales ; from this point it continues in a straight line to the root of the caudal fin terminating at the middle point ; the number of perforated scales in the lateral line is one hundred and forty-four. In the transverse lateral series there are eleven rows of scales between the first dorsal fin and the lateral line and twenty-five rows of scales between the lateral line vertically below the anterior origin of the first dorsal fin and the midventral line [*i.e.* lat. trans. at the first dorsal fin, is 11/25], between the second dorsal fin and the lateral line there are sixteen rows of scales, and between the lateral line at the point in the line directly below the anterior origin of the second dorsal fin and the midventral line there are fifteen rows of vertical scales [*i.e.* lat. trans. at the second dorsal fin, is 16/15]. The number of lateral rows of scales, between the anterior origin of the first dorsal fin and the ventral fin of the same side, is thirty-five.

The colour of the specimens in alcohol is brown above the lateral line, and dull silvery white below that line including the abdomen. The fins are pale brown and, except the ventral fins, the inner margins of the fins are tinted black. The tip of the lower jaw with the fleshy protuberance is coloured black. The upper margins of the rims of the eyes are also black. The roots of the dorsal fins, specially of the second dorsal, are coloured black. On the side of the body there are short and thick but faint oval patches, six or seven in number, along the middle line below the two dorsal fins. These faint marks are only visible in shaded light. The tip of the tongue and the top of the end of the upper jaw are dark.

The new species differs from all the known Indian species by possessing a very large number of scales in the lateral line as well as in the proportions of the different parts and in the position of the fins. The new fish has a longer head than *S. jellow*, *S. acutipinnis*, *S. commersonii* and *S. obtusata* ; it is of lesser height and has smaller

eyes than *S. obtusata*. In the number of scales in the lateral line it approaches *Sphyraena sphyraena* (L.), more commonly known as *Sphyraena vulgaris*, which has one hundred and fifty scales in the lateral line against one hundred and forty-four in the new species; the new species is a deeper fish than *S. sphyraena* and possesses larger eyes. From all the recently described species of the genus it differs considerably. From *S. africana*, Gilchrist,[1] it differs in the character of its teeth, in possessing a smaller eye and a shorter maxillary, in having the pectoral fin not ending below the origin of the spinous dorsal and not having the ventrals in advance of the origin of the first dorsal, besides other differences. *S. ensis*, Jordan and Gilbert,[2] has a longer head, a less deep body, a larger eye and longer maxillary. *S. goodingi*, Seale,[3] is much less deep, possesses short gill-rakers (gill-rakers are absent in the new species) and differs in the position of the fins. *S. pelleri*, Jenkins,[4] has longer eyes and is much less deep than the new species and differs in the number of rows of scales on the cheek. *S. putnamiae*, Jordan and Seale,[5] differs in the length of the maxillary and also in the character of the teeth, in the proportions of the fins and in colouration.

The new species differs from *S. pinguis*, Günther,[6] in the character of the tip of the lower jaw, in the position of the fins and in the number of scales in the lateral line. *S. snodgrassi*, Jenkins,[7] has a larger eye, longer maxillary and a smaller number of scales in the lateral line. *S. tome*, Fowler,[8] differs in the depth of the body, in the number of scales in the lateral and transverse lines, in the width of the head and in the depth of the caudal peduncle, etc. *S. waitii*,[9] Ogilby, differs in every particular except in the height of the body and the length of the head.

The type-specimen was collected at Satpara in the outer channel of the lake. The period of its capture is not noted. Evidently the species is an occasional visitor to the part of the lake that is nearest to the sea. The type is 210 mm. in length without the caudal fin and is entered in the register of the Zoological Survey of India under No. F. 9453/1.

Family OPHIOCEPHALIDAE.

Genus **OPHICEPHALUS**, Bloch.

Ophicephalus punctatus, Bloch.

1801. *Ophicephalus punctatus*, Bloch, *Ichth.*, X, p. 114, pl. ccclviii.
1803. *Ophiocephalus karrouvei*, Lacepede, *Hist. Poiss.*, III, p. 554.
1822. *Ophiocephalus lata*, Hamilton Buchanan, *Fish. Ganges*, pp. 63 and 367.
1831. *Ophicephalus punctatus*, Cuvier and Valenciennes, *Hist. Nat. Poiss.*, VII, p. 404.

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[1] Gilchrist, *Ann. South African Mus.*, VI, p. 256 (1908-10).
[2] Jordan and Gilbert, *Bull. U. S. Fish. Com.*, II, p. 106 (1882).
[3] Seale, *Occasional Papers Ber. Pau. Bishop Mus. Honolulu*, IV, p. 18 (1906).
[4] Jenkins, *Bull. U. S. Fish. Com.*, XIX, p. 387 (1899).
[5] Jordan and Seale, *Proc. Davenport Acad. Sc.*, X, p. 4, pl. xiii (1907).
[6] Günther, *Journ. Mus. Godeffroy*, II, p. 211 (1873).
[7] Jenkins, *Bull. U. S. Fish. Com.*, XIX, p. 387 (1899).
[8] Fowler *Proc. Acad. Nat. Sc. Philadelphia*, LV, p. 750, pl. xlvi (1903).
[9] Ogilby, *Ann. Queensland Mus.*, IX, p. 29 (1908).

1842. *Ophicephalus indicus*, M'Clelland, *Cal. Journ. Nat. Hist.*, II, p. 583.
1848. *Ophiocephalus punctatus*, Jerdon, *Madras Journ. Lit. Sc.*, p. 145.
1853. *Ophiocephalus punctatus*, Bleeker, *Verh. Bat. Gen.*, XXV, p. 95.
1861. *Ophiocephalus punctatus*, Günther, *Cat. Fish. Brit. Mus.*, III, p. 469.
1861. *Ophiocephalus affinis*, *Id.*, *ibid.*, p. 470.
1865. *Ophiocephalus punctatus*, Day, *Fish. Malabar*, p. 151.
1878. *Ophiocephalus punctatus*, *Id.*, *Fish. Ind.*, p. 367, pl. lxxviii fig. 1.
1889. *Ophiocephalus punctatus*, *Id.*, *Faun. Brit. Ind. Fish.*, II, p. 364.
1909. *Ophiocephalus punctatus*, Jenkins, *Rec. Ind. Mus.*, III, p. 287.
1910. *Ophiocephalus punctatus*, *Id.*, *ibid.*, V, p. 138.
1911. *Ophiocephalus punctatus*, Chaudhuri, *ibid.*, VI, p. 23.

There are two specimens in the collection ; one measuring 148 mm. in length is from Parikud. The other, 108 mm. in length, was secured in the month of September, 1914 at Barkul. In Parikud the fish was probably introduced through human agency. The presence of the fish in September near Barkul, when the water of this part of the lake is almost fresh, is easily accounted for.

Distribution :—Fresh waters of the East Indian continent and of Ceylon ; Yunnan.

Suborder PLECTOGNATHI.

Division *SCLERODERMI.*

Family TRIACANTHIDAE.

Genus **TRIACANTHUS**, Cuvier.

Triacanthus brevirostris, Temminck and Schlegel.

1754. *Balistes* sp., Gronovius, *Mus. Ichthyol.*, I, p. 52, pl. cxv.
1763. *Balistes bipes*, Gronovius, *Zoophyl.*, p. 53, pl. cccxciv.
1803. *Balistes* sp. (*Bowree and Abatoo*), Russell, *Fish. Vizag.*, I, p. 14, pl. xxi.
1830. *Balistes biaculeatus*, Bennett, *Fish. Ceylon*, p. 15, pl. xv.
1849. *Triacanthus biaculeatus*, Cantor, *Journ. Asiat. Soc. Bengal*, p. 1342.
1850. *Triacanthus brevirostris*, Temminck and Schlegel, *Faun. Japon. Pisces.*, p. 294, pl. cxxix, fig. 2.
1854. *Balistes bipes*, Gronovius and Gray, *Cat. Fish. Brit. Mus.*, p. 37.
1854. *Triacanthus brevirostris*, Hollard, *Ann. Sc. Nat.*, I, p. 45, pl. ii, fig. 1.
1865. *Triacanthus biaculeatus*, Day, *Fish. Malabar*, p. 260.
1870. *Triacanthus brevirostris*, Günther, *Cat. Fish. Brit. Mus.*, VIII, p. 210.
1878. *Triacanthus brevirostris*, Day, *Fish. Ind.*, p. 685, pl. clxxv, fig, 1.
1889. *Triacanthus brevirostris*, *Id.*, *Faun. Brit. Ind. Fish.*, II, p. 471, fig. 170.
1903. *Triacanthus brevirostris*, Regan, *Proc. Zool. Soc.*, I, pp. 181 and 183.
1910. *Triacanthus brevirostris*, Annandale and Jenkins, *Mem. Ind. Mus.*, III, pp. 8 and 11.
1910. *Triacanthus brevirostris*, Jenkins, *Rec. Ind. Mus.*, V., p. 136.
1912. *Triacanthus brevirostris*, *Id.*, *ibid.*, VII, p. 6.

The specific name "*bipes*" by Dr. Laurence Theodore Gronow is the earliest, reported to be written before 1777 and said to be published in 1780. The species was described by Gronow as early as 1754 (Mus. Ichthyol.[1]).

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[1] "Catalogue of Fish collected and described by Laurence Theodore Gronow now in the British Museum." Published by order of the Trustees, in 1854; edited by J. E. Gray, pp. v-vii and 37.

There are fifty-seven specimens in the collection. This fish occurs very extensively all over the lake and breeds freely everywhere at least from February to September. Numerous young measuring 12 mm. and upwards were secured in March, June, July and September. Some of the young have black or grey blotches or stripes. The following statement shows the different localities in the lake whence the specimens were obtained, and their number and size.

2 specimens	Off Balugaon	21-vii-13	28 mm. and 40 mm.
9 ,,	Off Barkul	13-xi-12	24 ,, to 56 ,,
3 ,,	Between Chiriya Island and Barkuda Island	17-xi-14	255 ,, to 275 ,,
10 ,,	Between Domkuda and Samal Island	July, 1914	12 ,, to 23 ,,
3 ,,	Off Nalbano	Sept. 1914	24 ,, to 53 ,,
1 specimen	South East of Patsahanipur	6-iii-14	12 ,,
1 ,,	Rambha Bay	——	86 ,,
21 specimens	Off Samal Island	22-ix-13	11 ,, to 47 ,,
6 ,,	Seruanaddi near Barnikuda	4-ix-14	17 ,, to 46 ,,
1 specimen	Seruanaddi	8-ix-14	46 mm.

This fish is eaten by the Uriyas among whom it commands a very extensive sale and is extremely cheap; it is very popular with the poorer classes of the people round the lake; even the skin, spines and bones separately find a ready market.

Distribution :—Seas of India, of the Malay Archipelago, China and Japan; also Australia.

Division *GYMNODONTES.*

Family TETRODONTIDAE.

Genus **TETRODON**, Linnaeus.

Tetrodon fluviatilis, Hamilton Buchanan.

1822. *Tetrodon fluviatilis*, Hamilton Buchanan, *Fish. Ganges*, pp. 6 and 362, pl. xxx, fig. 1.
1823. *Tetrodon nigroviridis*, Procé, *Bull. Soc. Philom.* (1822), p. 130.
1849. *Tetrodon simulans*, Cantor, *Journ. Asiat. Soc. Bengal*, p. 1356.
1860. *Arothron dorsovittatus*, Blyth, *ibid.*, XXIX, p. 173.
1865. *Crayracion fluviatilis*, Bleeker, *Atl. Ichthyol. Ind. Orient. Neerl.*, p. 68, pl. ccx, fig. 4.
1865. *Crayracion fluviatilis*, Day, *Fish. Malabar*, p. 256.
1870. *Tetrodon fluviatilis*, Günther, *Cat. Fish. Brit. Mus.*, VIII, p. 299.
1878. *Tetrodon fluviatilis*, Day, *Fish. Ind.*, p. 707, pl. clxxxiii, fig. 1.
1889. *Tetrodon fluviatilis*, *Id.*, *Faun. Brit. Ind. Fish.*, II, p. 496.
1902. *Tetrodon fluviatilis*, Regan, *Proc. Zool. Soc.*, 1902 (ii), p. 284.
1910. *Tetrodon fluviatilis*, Annandale and Jenkins, *Mem. Ind. Mus.*, III, pp. 8 and 15.

There are only three young specimens in the collection, one measuring 44 mm. in length caught off Nalbano in September, 1914 and two measuring 70 mm. and 72 mm. in length from Rambha Bay in February, 1914. The fish is probably a permanent inhabitant in the main area of the lake and breeds in it.

Distribution :—Seas and estuaries of India and the Malay Archipelago. This

species appears to be entirely littoral, estuarine and fluviatile. It ascends tidal rivers and has been reported as far up as Saraghat in the Ganges. In the Amherst District of Burma it is said to be found in hill streams.

Tetrodon oblongus (Bloch).

1785. *Tetraodon oblongus*, Bloch, *Ausl. Fisch.*, II, p. 6, pl. cxlvi, fig. 1.
1801. *Tetraodon oblongus*, Bloch and Schneider, *Syst. Ichthyol.*, p. 504.
1803. *Tetraodon* sp. (*Kappa*), Russell, *Fish. Vizag.*, I, p. 17, pl. xxiv.
1846. *Tetrodon alboplumbeus*, Richardson, *Voy. Sulph. Ichthyol.*, p. 121, pl. lviii, figs. 6 and 7.
1846. *Tetrodon alboplumbeus*, *Id.*, *Rept. Brit. Assoc. Adv. Sc.* (1845), p. 199.
1849. *Tetrodon oblongus*, Cantor, *Journ. Asiat. Soc. Bengal* (1849), p. 1362.
1860. *Gastrophysus microphthalmus*, Blyth, *Journ. Asiat. Soc. Bengal*, XXIX, p. 174.
1870. *Tetrodon oblongus*, Günther, *Cat. Fish. Brit. Mus.*, VIII, p. 278.
1878. *Tetrodon oblongus*, Day, *Fish. Ind.*, p. 702, pl. clxxx, fig. 2.
1889. *Tetrodon oblongus*, *Id.*, *Faun. Brit. Ind. Fish.*, II, p. 492.
1910. *Tetrodon oblongus*, Annandale and Jenkins, *Mem. Ind. Mus.*, III, pp. 8 and 14.

There is only one young specimen in the collection measuring 67 mm. in length ; locality and date of capture are not noted. Probably the fish is a chance visitor to the outer channel.

Distribution :—Seas of India ; Indian Ocean ; Malay Archipelago ; China, Japan and the South Sea.

Tetrodon patoca, Hamilton Buchanan.

1803. *Tetraodon* sp. (Kappa), Russell, *Fish. Vizag.*, p. 18, pl. xxv.
1822. *Tetrodon patoca*, Hamilton Buchanan, *Fish. Ganges*, pp. 7 and 363, pl. xviii, fig. 2.
1849. *Tetrodon dissutidens*, Cantor, *Journ. Asiat. Soc. Bengal* (1849), p. 1364.
1855. *Tetrodon patoca*, Duméril, *Rev. Zool.*, p. 280.
1865. *Leiodon patoca*, Bleeker, *Atl. Ichthyol. Ind. Orient. Neerl.* V, p. 76, pl. vi, fig. 2.
1870. *Tetrodon patoca*, Günther, *Cat. Fish. Brit. Mus.*, VIII, p. 288.
1878. *Tetrodon patoca*, Day, *Fish. Ind.*, p. 703, pl. clxxxii, fig. 4.
1889. *Tetrodon patoca*, *Id.*, *Faun. Brit. Ind. Fish.*, II, p. 492.
1910. *Tetrodon patoca*, Annandale and Jenkins, *Mem. Ind. Mus.*, III, p. 14.

There are three specimens in the collection all of which are young, measuring 12 mm., 13 mm. and 25 mm. in length. They were collected in the latter half of the month of March, 1913 and 1914 in Satpara Bay and near Satpara. Probably the fish comes as far as the outer channel and breeds in the neighbourhood in February and March, when the water is nearly as salt as the sea outside.

Distribution :—From Sind through the seas of India to China. The fish is very common along the Coromandel coast. The species is also common in the estuaries of the Ganges.

Tetrodon reticularis (Bloch and Schneider).

1785. *Tetraodon testudineus*, Bloch, *Ausl. Fisch.*, I, p. 123, pl. cxxxix.
1801. *Tetraodon testudineus*, Bloch and Schneider, *Syst. Ichthyol.*, p. 502.
1801. *Tetraodon reticularis*, *Id.*, *ibid.*, p. 506.
1803. *Tetraodon* sp. (*Bondaroo Kappa*), Russell, *Fish. Vizag.*, I, p. 19, pl. xxvii.
1804. *Tetrodon testudineus*, Shaw, *Gen. Zool.*, V, p. 444, pl. clxxviii.

1849. *Tetrodon testudineus*, Cantor, *Journ. Asiat. Soc. Bengal* (1849), p. 1358.
1865. *Crayracion testudineus*, Bleeker, *Atl. Ichthyol. Ind. Orient. Neerl.*, V, p. 71, pl. ccxii, fig. 3.
1865. *Crayracion testudineus*, Day, *Fish. Malabar*, p. 257.
1870. *Tetrodon reticularis*, Günther, *Cat. Fish. Brit. Mus.*, VIII, p. 296.
1878. *Tetrodon reticularis*, Day, *Fish. Ind.*, p 705, pl. clxxx, fig. 5.
1889. *Tetrodon reticularis*, *Id.*, *Faun. Brit. Ind. Fish.*, II, p. 494.
1910. *Tetrodon reticularis*, Annandale and Jenkins, *Mem. Ind. Mus.*, III, p. 8.

There are only two specimens in the collection, one measuring 145 mm. in length secured in March, 1914 near Satpara, and the other measuring 112 mm. in length obtained in the channel between Barnikuda and Satpara on 4-ix-14. Probably the fish is an occasional visitor to the outer channel when the salinity of the area is sufficiently high.

Distribution :—Seas of India, Malay Archipelago and New Guinea.